No.353

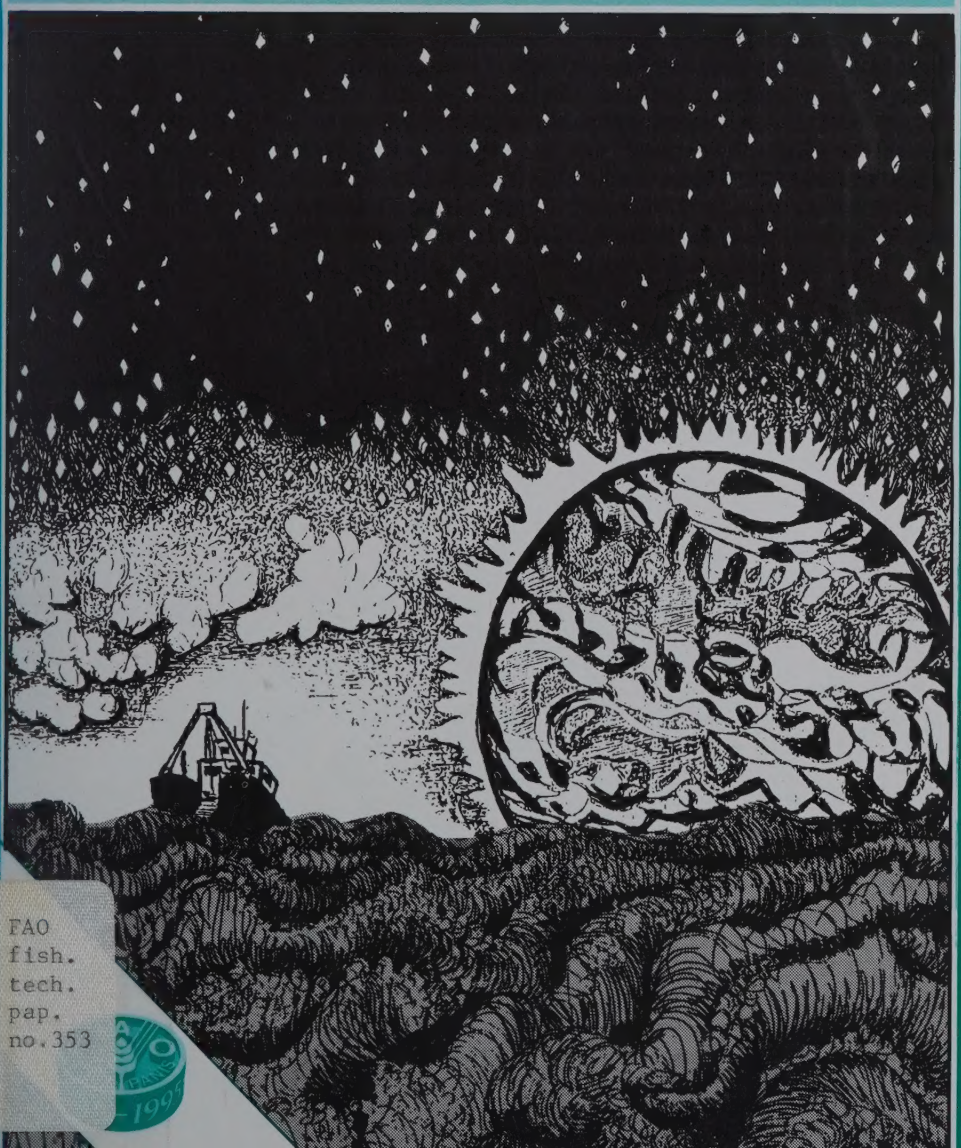
ISSN 0429-9345

FAO
FISHERIES
TECHNICAL
PAPER

353

# Living marine resources and their sustainable development

## Some environmental and institutional perspectives



FAO
fish.
tech.
pap.
no.353

Food
and
Agriculture
Organization
of
the
United
Nations

# Living marine resources and their sustainable development

## Some environmental and institutional perspectives

**J.F. Caddy**
Marine Resources Service
FAO Fisheries Department
and
**R.C. Griffiths**
Consultant
Saint Cloud, France

LIBRARY

JUL 08 1996

National Marine Fisheries Service
2570 Dole Street
Honolulu, Hawaii

FAO
fish
tech.
pap
no 353

FAO
FISHERIES
TECHNICAL
PAPER

353

Food
and
Agriculture
Organization
of
the
United
Nations

Rome, 1995

The designations employed and the presentation of material in this publication do not imply the expression of any opinion whatsoever on the part of the Food and Agriculture Organization of the United Nations concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries.

M-43
ISBN 92-5-103763-9

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means, electronic, mechanical, photocopying or otherwise, without the prior permission of the copyright owner. Applications for such permission, with a statement of the purpose and extent of the reproduction, should be addressed to the Director, Publications Division, Food and Agriculture Organization of the United Nations, Viale delle Terme di Caracalla, 00100 Rome, Italy.

© FAO 1995

## PREPARATION OF THIS DOCUMENT

The first draft of this paper was prepared at the invitation of the Secretariat of the United Nations Conference on Environment and Development (UNCED) in July 1991, and summarized as UNCED Research Paper No. 5, entitled "Living Marine Resources" for use as a background paper in preparation for the Conference in Rio de Janeiro, June 1992.

The document has been extensively revised subsequently to reflect events since the Earth Summit '92, and is intended to perform the following functions, notably:

- To be a companion volume to the Review of the State of World Marine Fishery Resources", issued by the Marine Resources Service in 1994 as FAO Fisheries Technical Paper 335;

- To serve as a discussion and reference paper at meetings which discuss marine resource policy in relation to the environment;

- To function as a source paper for key publications and conference documents over a broad range of related subject areas;

- To provide a broad environmental perspective to discussions on marine resource use policy in the light of Agenda 21, as well as relevant issues from the 1982 Convention on the Law of the Sea; the Cancun Conference on Responsible Fishing, and relevant documents from the 1992 FAO Committee on Fisheries, among others.

The authors express their gratitude to many colleagues for inputs made; in particular to Mr. Uwe Barg for useful input, and to Ms Jackie Ellis and Mrs Raymonde Véry-Marotta who were responsible for final typing.

*Distribution*:

FAO Fisheries Department
FAO Regional fisheries Officers
Directors of Fisheries
Regional and International Fisheries Organizations
Authors

Caddy, J.F.; Griffiths, R.C.
**Living marine resources and their sustainable development: some environmental and institutional perspectives.**
*FAO Fisheries Technical Paper.* No. 353. FAO, Rome. 1995. 167p.

ABSTRACT

This document provides a broad perspective on issues related to living marine resources, their environment and management in the post-UNCED context provided by Agenda 21 and the Cancun Conference. The document begins with a sectorial discussion of sustainable development of living resources of nearshore and estuarine, semi-enclosed seas, coastal and shelf waters, the high seas and Antarctic waters. Constraints on harvesting, impacts of marine pollution, and potentials for further development of resources are addressed. Each section concludes with a discussion of elements that can be included in a programme for addressing resource management, and provides a list of references on key literature related to the themes discussed, and a series of annexes which provide a glossary of key concepts, list of acronyms, list of fisheries commissions, International Organizations concerned with marine affairs, excerpts from conventions and other international agreements relating to living marine resources and their environment.

## TABLE OF CONTENTS


| | | |
|---|---|---|
| **1.** | **INTRODUCTION** | 1 |
| 1.1 | OVERALL OBJECTIVES | 1 |
| 1.2 | SUSTAINABLE DEVELOPMENT AND WILD FISHERIES | 2 |
| **2.** | **THE STATE OF LIVING MARINE RESOURCES AND THEIR ENVIRONMENT** | 11 |
| 2.1 | NEARSHORE AND ESTUARINE RESOURCES AND THEIR ENVIRONMENT | 11 |
| **2.1.1** | **Coastal Zones, Coastal Populations and Coastal Resources** | 11 |
| **2.1.2** | **Fisheries in Estuaries and along the Coastal Fringe** | 14 |
| **2.1.3** | **Coastal Marine Aquaculture** | 17 |
| **2.1.4** | **Eutrophication and the Special Case of Phosphorus** | 17 |
| **2.1.5** | **Other Ocean-Atmospheric Linkages** | 20 |
| **2.1.6** | **Proposed Actions** | 20 |
| 2.2 | COASTAL AND SHELF-SEA RESOURCES AND THEIR ENVIRONMENT | 22 |
| **2.2.1** | **The Exploitation of Shelf Resources** | 22 |
| **2.2.2** | **Environmental Impacts on Shelf-Sea Resources** | 25 |
| **2.2.3** | **Resource Enhancement Measures** | 27 |
| **2.2.4** | **Management of Coastal and Shelf-Sea Fisheries** | 27 |
| **2.2.5** | **Proposed Actions** | 32 |
| 2.3 | RESOURCES AND ENVIRONMENTS OF ENCLOSED AND SEMI-ENCLOSED SEAS | 33 |
| **2.3.1** | **Categorization of Semi-Enclosed Seas** | 33 |
| **2.3.2** | **Impact of Human Activities** | 34 |
| **2.3.3** | **Potentials and Constraints for Sustainable Development** | 38 |
| **2.3.4** | **Proposed Actions** | 39 |
| 2.4 | RESOURCES AND ENVIRONMENT OF THE HIGH SEAS AND THE OPEN OCEAN | 41 |
| **2.4.1** | **Oceanic Resources and High-Seas Fisheries** | 41 |
| **2.4.2** | **The Open-Ocean Environment** | 41 |
| **2.4.3** | **Management of High-Seas Fisheries** | 42 |
| **2.4.4** | **Proposed Actions** | 46 |
| 2.5 | ANTARCTIC RESOURCES AND THEIR ENVIRONMENT | 46 |
| **2.5.1** | **State of the Resources** | 46 |
| **2.5.2** | **Protection Measures** | 47 |
| **2.5.3** | **Proposed Actions** | 48 |
| 2.6 | APICAL PREDATORS, MARINE MAMMALS, REPTILES, BIRDS AND ENDANGERED SPECIES | 48 |
| **2.6.1** | **Proposed Actions** | 50 |

3. **SHORT-TERM AND LONG-TERM VARIABILITY IN THE MARINE ENVIRONMENT** 51

4. **THE OPTIMUM HARVESTING OF LIVING MARINE RESOURCES** 52

4.1 FISHERY MANAGEMENT OBJECTIVES 52

4.2 DESTRUCTIVE FISHING PRACTICES AND OVERFISHING 55
**4.2.1 The effects of Fishing Gear on the Ecosystem** 55
**4.2.2 Fleet Expansion and Over-Capitalization** 55

4.3 STOCK RECOVERY AFTER OVER-EXPLOITATION 56

4.4 RESPONSIBLE FISHING 56
**4.4.1 General Considerations** 56
**4.4.2 The Precautionary Principle** 60
**4.4.3 New Options for Sustainable Harvesting** 62

5. **IMPACTS ON FISH STOCKS OTHER THAN THOSE DUE TO FISHING** 64

5.1 MARINE POLLUTION 65
**5.1.1 Waste Disposal at Sea and Environmental Receiving Capacity** 66
**5.1.2 Safety of Aquatic Products** 66

5.2 COASTAL CONSTRUCTION 67

5.3 COASTAL INDUSTRY 67

5.4 MARINE MINING 68

5.5 TOURISM AND RECREATION 68

5.6 COASTAL AQUACULTURE 69

5.7 COASTAL SHIPPING 69

5.8 POTENTIAL IMPACTS OF AGRICULTURE ON THE MARINE CATCHMENT BASIN 70

5.9 INTRODUCTION OF EXOTIC SPECIES AND THE BIODIVERSITY ISSUE 70

5.10 POTENTIAL IMPACTS OF GLOBAL CHANGES ON MARINE RESOURCES 71

5.11 INTEGRATED COASTAL AREA MANAGEMENT 72

6. **THE ROLE OF RESEARCH, TECHNOLOGY AND MONITORING** 73

6.1 MARINE SCIENTIFIC RESEARCH 73

6.2 APPLICATION OF NEW TECHNOLOGY 76

6.3 STOCK MONITORING 76

**7. THE INTERNATIONAL FRAMEWORK FOR SUSTAINABLE DEVELOPMENT AND LIVING MARINE RESOURCE USE 78**

7.1 THE 1982 CONVENTION ON THE LAW OF THE SEA 78
**7.1.1 Shared stocks** 78

7.2 MAJOR INTERNATIONAL EVENTS SUBSEQUENT TO NEGOTIATION OF THE 1982 CONVENTION 80

7.3 THE UN CONFERENCE ON ENVIRONMENT AND DEVELOPMENT AND AGENDA 21 80

7.4 THE ROLE OF INTERNATIONAL ORGANIZATIONS 82

7.5 THE EFFECTIVENESS OF FISHERY COMMISSIONS AND CONVENTIONS 83
**7.5.1 Proposed actions** 86

**8. SELECTED REFERENCES** 91

**ANNEX I: SOME RECENT CHANGES IN PERCEPTION OF MARINE RESOURCES AND ENVIRONMENT: A SHORT GLOSSARY OF RELEVANT CONCEPTS 119**

**ANNEX II: LIST OF ACRONYMS 129**

**ANNEX III: SOME INTERNATIONAL ORGANIZATIONS INVOLVED WITH (THE) OCEANIC ENVIRONMENT AND LIVING MARINE RESOURCES 131**

**ANNEX IV: EXTRACTS FROM THE 1982 LAW OF THE SEA CONVENTION OF PARTICULAR RELEVANCE TO LIVING MARINE RESOURCES 141**

**ANNEX V: THE CANCUN DECLARATION 149**

**ANNEX VI: THE RIO DECLARATION 153**

**ANNEX VII: EXTRACTS FROM AGENDA 21 FOR THE OCEANS 157**

**ANNEX VIII: THE UNITED NATIONS CONVENTION ON BIOLOGICAL DIVERSITY 167**

# 1. INTRODUCTION

## 1.1 OVERALL OBJECTIVES

Developing a strategy to ensure the sustainable use of living marine resources and their environment was only one aspect of man's relationship with the biosphere addressed at the UN Conference on Environment and Development (Rio de Janeiro, June 1992). However, this aspect poses particular problems for international collaborative management that do not apply to most terrestrial environments, where the ownership of resources and their environment, and the corresponding responsibility for their management, have usually been long established. The urgent need now is how to establish the conditions for **sustainable development** of living marine resources within the existing framework of rights and responsibilities for different maritime areas and resources. The beginnings of a consensus on this issue effectively date from the United Nations Convention on the Law of the Sea in 1982 (United Nations, 1983)[1] which is used by most of the signatory States as a basis for relevant national and international legislation and State practice. The Convention came formally into force in November 1994.

However, many of the coastal States signatory to this Convention have not yet adequately evaluated the potential of the resources at their disposal, nor developed strategies for allocating to their own citizens the rights to, and responsibilities for, the marine resources within the maritime zones under their respective jurisdictions or sovereignty (notably, Exclusive Economic Zones). Nor have they all decided on conditions of access to foreign fishing vessels. Still fewer have developed frameworks for necessary collaboration with neighbouring countries sharing the same unit resources and protecting their common marine environment.

On a technical level, the fact that the living resources of seven-tenths of the world's surface (i.e., the oceans and seas) are made up of communities of wild animals, differentiates the use of these resources and their environments from the artificial mono- or polyculture systems of domesticated plants and animals typical of much of the productive land surface and of marine aquaculture. Consequently, the sustainable development of the living resources of the world's oceans has more in common with wildlife management than with most uses of terrestrial systems. The contrast between systems of culture of domestic animals and plants and the harvest of wild resources is simply stated: in the former case, the resource is usually harvested at an optimal age; in the latter case, the harvest is of a mixture of age groups, often containing mature and immature individuals, and often accompanied by other components of the ecosystem, whether of commercial value or otherwise, which if not retained by the harvester, usually experience discard mortality when returned to the sea.

Experience has shown that removing an excessively high proportion of such a continuously harvested renewable resource will compromise its sustainability and therefore the supply of food to future generations of human beings. For this reason, the concepts of conservation, development and access need to be reconciled before serious progress can be achieved in marine resource management.

---

[1] Referred to as "the 1982 Convention" in this document.

## 1.2 SUSTAINABLE DEVELOPMENT AND WILD FISHERIES

Any discussion of the sustainable development (see definitions below) of the marine environment and its resources leads inevitably to a need for familiarity with a wide range of technical subjects, particularly with respect to living marine resources, their biology and environment. To avoid excessive technical vocabulary and explanations within the main body of the document, the reader is referred to Annex I which provides a brief glossary of some of the main terms and concepts used in this paper. However, certain basic terms and concepts need to be defined and discussed at once.

In view of the intimate connection between resources and their environment, and for the sake of convenience, the term **resources** will, hereafter, be generally used to refer to the **living marine species** potentially or presently subject to exploitation by man for food, feed, fertilizer or the production of other products of value or use, it being understood that a living marine resource cannot be dissociated from its environment. Moreover, the term **fish** will be generally used to cover fish proper, as well as shellfish and all other groups of marine organisms exploited for human use or consumption.

The International Union for the Conservation of Nature (IUCN) and definition of **conservation** given in the "World Conservation Strategy" (IUCN, UNEP and WWF, 1980), is "the management of human use of the biosphere so that it may yield the greatest sustainable benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations".

The same document defines **development** as "the modification of the biosphere and the application of human, financial, living and non-living resources to satisfy human needs and improve the quality of human life". The apparent incompatibility of these two processes led to the concept of **sustainable development** which is discussed below.

The concept of **sustainable development** was at the core of the debate at the 1992 UN Conference on Environment and Development in Rio de Janeiro. The need for sustaining improvements in human well-being, while pursuing policies compatible with the capacity of the global environment to sustain them over the long term, has led in recent years to the ideal of **sustainable development.** This concept embodies the idea of "progress", the motive force for technologically driven changes since the middle of the last century, and the idea of "stability", the ability of mankind to extract a constant level of benefits from an ecosystem over an indefinite period. The more limited notion of **development** therefore embodies the notion of exploitation or harvesting of natural resources; however, such exploitation must be constrained by the capacity of the exploited resource and its natural environment to resist the impact of exploitation, if such development is to be **sustainable.** The pursuit of "progress" without restrictions has had negative effects on marine, as well as terrestrial, environments; this document briefly describes these effects for the marine environment without going into detail.

Various definitions have been proposed for this new, environmentally more appropriate, approach to development. The definition of **sustainable development** adopted by the World Commission on Environment and Development in 1987 (Anon, 1987) is perhaps the simplest:

> *"Development that meets the needs of the present without compromising the ability of future generations to meet their own needs."*

This definition recognizes that the value systems of society are continuously changing, as will the relative value currently assigned to a particular living resource.

A more explicit definition for aquatic and terrestrial systems, adopted by the 94th FAO Committee on Fisheries in 1991 (COFI 1991), is:

> *"Sustainable development is the management and conservation of the natural resource base, and the orientation of technological and institutional change in such a manner as to ensure the attainment and continued satisfaction of human needs for present and future generations. Such development conserves land, water, plant and genetic resources, is environmentally non-degrading, technologically appropriate, economically viable and socially acceptable."*

Clearly, this definition places the satisfaction of human needs in a central position, and recognizes, as does the concept of **intergenerational equity** mentioned at UNCED, that fishers have a right to a livelihood, but a responsibility to see that their offspring, and the following generations, have similar prospects. Clearly to satisfy this statement of equity it will be necessary that such fishers leave the resource: 'in, or close to, the same state that they found it in'. To achieve this result, a **Code of Conduct for Responsible fishing** is being developed by FAO at the request of its member countries, first expressed at the 1993 Cancún Conference (FAO, 1992c).

The FAO Committee on Fisheries definition of **sustainable development** was primarily aimed at the harvesting of resources, but could also apply to recreational or other uses that do not lead primarily to resource depletion. It is clearly intended to encompass three main types of activity:

(1) those activities that fall within the classical concept of development, namely, the economic growth resulting from newly exploited resources, without compromising the capacity of the resource base and its environment to sustain the exploitation;

(2) any modification of the level of use of resources that are already being exploited, while diversifying this use so as to render exploitation more productive and cost effective, and to reduce the impacts of resource use on other components of the ecosystem and on other human endeavours;

(3) the rehabilitation of ecosystems degraded by past destructive exploitation, so as to restore them to productive use.

It is clear that sustainability refers to the resources and also to the fishery that exploits them (Christie, 1993). In the marine context, however, it should be borne in mind that sustaining a resource and sustaining a fishery on that resource, are, in many respects, independent objectives.

To what extent, and under what conditions, are the above-mentioned criteria feasible objectives for man's use of marine life, and to what extent, and following what strategies, is sustainable development a feasible objective for management of marine resources? This document attempts to address such questions and to raise some related issues for future discussion. It is, however, clear that the achievement of sustainable development will involve a long struggle, with many hard lessons learned by each country as it attempts to apply general principles to its specific circumstances.

Beside fishing, other human activities, as well as natural changes, affect the marine environment and, consequently, the living marine resources they contain. Certain living marine resources and marine ecosystems resist well the impact of certain of these activities on the marine environment, in which case they are often described as "robust". Other marine

ecosystems and resources have little resistance, and are often called "fragile". Since the system and the source or cause of the impact need to be specified, these terms are often rendered meaningless or vague, since the so-called "fragile" ecosystems have been almost as successful in surviving so far, as the "robust" ones. The term "susceptible" is preferred, since the particular factors impacting the resource need to be specified.

The **susceptibility of a marine resource or an ecosystem** to changes induced by outside forces, such as pollutant inputs or climatic changes, has been defined by Sherman and Solow (1992). Starting from the concept of ecosystem "health", they consider the term to describe the resilience, stability and productivity of the ecosystem in relation to its changing state. Constanza (1992), considered that, for an ecosystem to be healthy and sustainable, it must maintain its metabolic activity, its internal structure and organization, and be resistant to external stress over relevant time and space scales. These conditions of health and sustainability can be measured in terms of five variables: diversity, stability, resilience, production and yield. Rapport *et al.* (1985) and Berkes *et al.* (1993), among others, have considered in some detail ecosystem behaviour under stress.

**Harvesting components from an ecosystem,** taps the continuous flow of energy and materials produced by the primary source of most organic material, using the sun's energy by photosynthesis, as it flows upwards through the food web towards the apical predators. Such a food web can be considered a "dissipation structure" in thermodynamic terms (Caddy and Sharp, 1984): harvesting one node of the food web too intensively, will cause energy to be diverted into other food web components which may not be so suitable for human needs.

**Diversity** indices are measures of richness (the number of species in a system); and to some extent, evenness (variances of species' local abundance) (Pielou, 1975). They are therefore indifferent to species substitutions which may, however, reflect ecosystem stresses (such as those due to high fishing intensity) (Pielou, *op. cit.*; Rapport *et al.*, 1985).

**Stability** implies the ability of all characteristic variables of a population/ecosystem to return towards initial equilibrium values following a disturbance that displaces that equilibrium. (The system is locally stable if the return is in response to local perturbations, and globally stable if it is stable when all the local perturbations cancel out when added up over the whole area of the species). It is worth noting here that past perceptions of a state of equilibrium or 'state of rest' to which populations return after being perturbed, is less well accepted by oceanographers and marine scientists. Long term fluctuations are more typical, often over decadal scales (Lluch-Belda *et al.*, 1992), to which the effects of climate change on marine systems can now be added (Ramanathan, 1988; Bakun, 1990).

**Resilience** is the rate of return of a stable population/ecosystem to its undisturbed equilibrium (Pimm, 1984), or more broadly, the ability of a system to maintain its structure and patterns of behaviour in the face of a disturbance (Holling, 1986).

**Production** in the strict sense, is the biomass generated by the population or ecosystem per-unit-time, whether or not this is harvested or consumed within the food web by other species (Allen, 1971). We often refer to "fisheries production" however, which is usually meant to include harvested biomass.

**Yield** is the amount of biomass that can be harvested without compromising the ability of the population/ecosystem to regenerate itself. The term **sustainable yield** is sometimes used in this same sense, as that yield which can be harvested without compromising the continuity of fishery production (Gulland, 1977); while noting that modern experience shows that this is not a constant value, and constantly varies in light of climatic regime changes.

Besides the glossary in Annex I which attempts to define some other useful terms, a list of acronyms is given in Annex II, and a list of selected references to further useful reading on the issues discussed here is given in section 8.

The kinds of responses likely to occur in a population of a species, hence in its ecosystem as a whole, are, for example, redistribution (to avoid an adverse environmental condition), changes in growth rate, mortality rate, fecundity, recruitment and in terms of **sustainable development**, it is obvious that a better understanding of the ecological susceptibility of a resource to forces leading to environmental change is a keystone of effective fishery management (Caddy and Sharp, 1986). The attainment of a steady state of development of any kind has been called into question (e.g. Simon 1989), and for marine fisheries it is clear that few fisheries landing trends show any form of stability (Caddy and Gulland, 1983; Hilborn and Walters, 1992), and the current paradigm is of resources showing wide fluctuations with environmental changes and economic cycles, resulting in fleet investment schemes which themselves usually depart widely from a steady state (Caddy, 1993b).

The distribution of biological production through the world's oceans, as for the distribution of living resources, is far from uniform (Fig. 1): the great majority of fishery production occurs within 200 miles of land; hence marine fishery resources are highly susceptible to the impacts of human activities.

The effects of the development of human activities on marine ecosystems has also not been uniform; some systems have shown considerable adaptability to high levels of human impact, whereas others have already been seriously affected. For this reason, this document treats the following ecological provinces separately within the global marine environment, with respect to the state of the resources and their environment, their development potentials, and the key actions considered necessary to promote **sustainable development**.

Although certain problems arise in more than one ecological province, it is practical to distinguish the following provinces:

(1) **nearshore waters and estuaries** - basically including the land-sea interface and the marine element of the coastal zone;

(2) **coastal and shelf seas** - the margins of oceans and open seas between the coastal zone and the edge of the continental shelf out to 200 miles and/or the 200-m isobath (which roughly corresponds in many areas to the limits of the Exclusive Economic Zone under the 1982 UN Convention on the Law of the Sea);

(3) **enclosed and semi-enclosed seas** - combining many of the considerations applicable to (1) and (2), above, but with the problems specific to such seas;

(4) **the high seas and open ocean** - the seas beyond the continental shelf and/or EEZ, not subject to any national jurisdiction;

(5) **the Antarctic** - the seas bordering the Antarctic continent, sometimes collectively referred to as the Southern Ocean; also not subject to any national jurisdiction, but presenting specific ecological characteristics not easily assimilable to any of the foregoing ecological provinces.

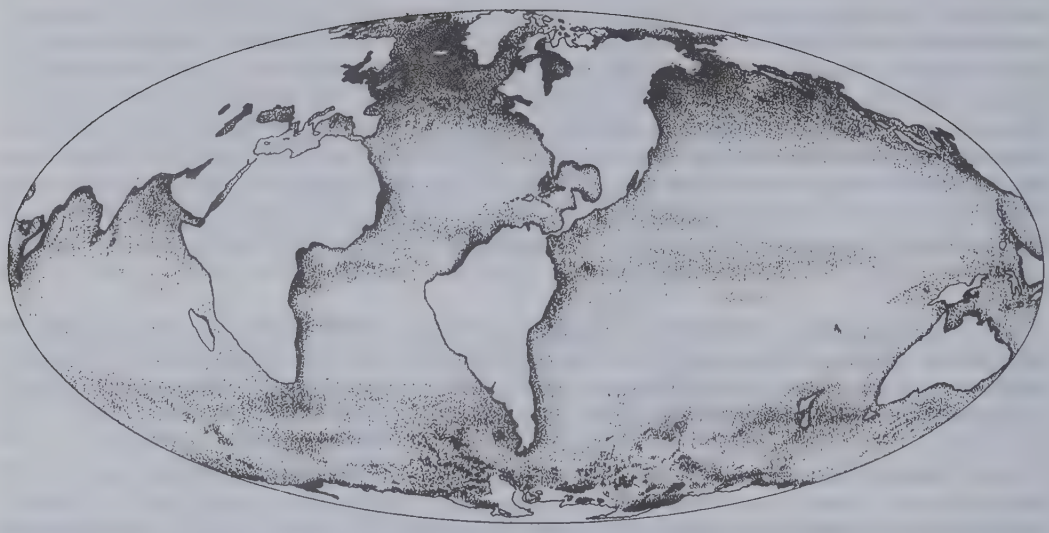


**Figure 1.** The first global view of the geographical distribution of the production of plants (phytoplankton) in the oceans forms the basis for food chains leading to marine fisheries, is redrawn from a composite image of ocean chlorophyll production based on remote sensing imagery for 1978-81 prepared under the NSF/NASA-sponsored, US Global Ocean Flux Study (from FAO, 1994b).

A separate section (2.6) is devoted to the special problems of apical predators, those species at the peak of the marine food chain, in the marine ecosystem and to endangered species, many of which are also apical predators.

The special problems of each province are dealt with in the respective sections, whereas the main problems common to all or most of these provinces are dealt with later in the document.

Although the initial approach is based on five major ecological provinces (sections 2.1. to 2.5), it may also be useful to consider alternative geographical/ecological subdivisions of the marine environment and its resources which may be applied to a consideration of the **sustainable development** of the resources (Fig. 2).

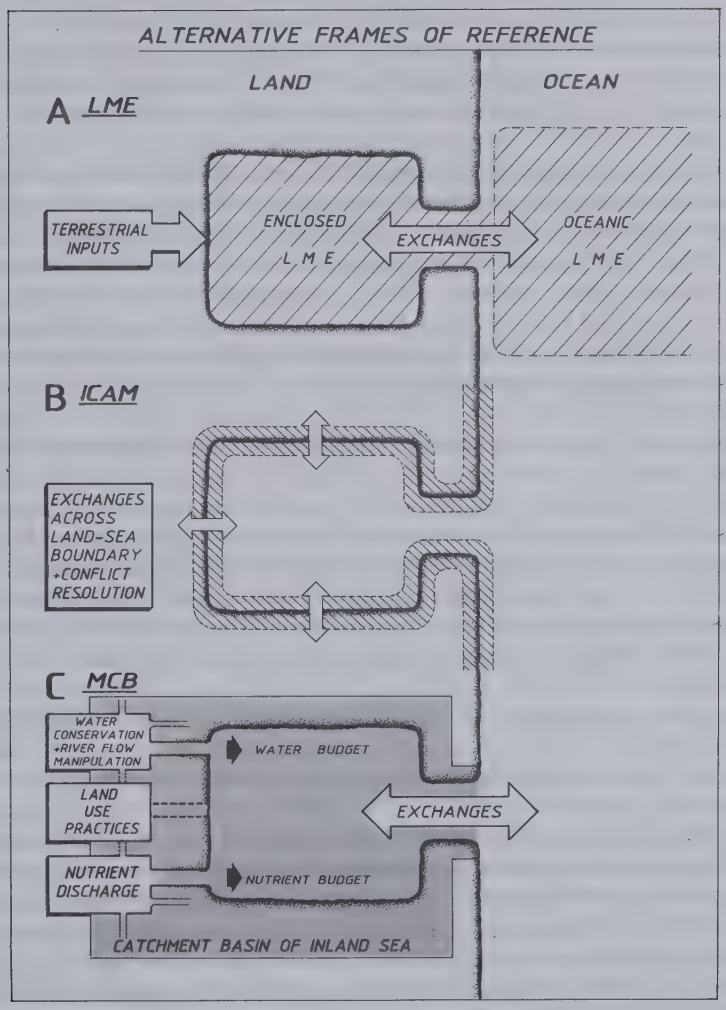



**Figure 2.** Three alternative frames of reference for studies on marine ecosystems illustrated for a semi-enclosed sea:
A: The large Marine Ecosystem Concept (LMG)
B: Integrated Water Area Management (ICAM)
C: The Marine Catchment Basin Approach (after Caddy, 1993a)

The concept of **Integrated Coastal Area Management** (ICAM) (see e.g. FAO, 1991c; Clark 1992; Chua and Fallon Scura, 1992; Pernetta and Elder, 1993) is obviously the context for discussion of the multiple interactions at the land-sea interface; in practice, this essentially means within roughly 5 km of this interface, although some activities, such as fishing and marine mining, taking place further offshore, or others, such as coastal construction, industrial installations and other activities affecting the exchanges at the land-sea interface, but occurring further inland, may also be of great importance to the marine environment but do not fall in the classical ICAM context. The main objective of Integrated Coastal Area Management is to harmonize those human activities which require for their success proximity to the land-sea interface in such a way as to minimize their impact on the coastal zone environment and natural resources. Such management requires some hard choices, and this subject is treated in somewhat more detail in section 5.11.

The **Marine Catchment Basin** (MCB) concept (Caddy, 1993a; Caddy and Bakun, 1995) aims at the integration of events within the catchment basins of rivers draining into the sea, with the ecology of the receiving sea itself. This approach (effectively that adopted for the Mediterranean Blue Plan and underlying the Helsinki Convention for the protection of the Baltic environment, Anon (1986); Ambio (1990)), is obviously relevant to estuaries, coastal lagoons and semi-enclosed and coastal seas where activities in marine and freshwater aquatic systems need to be integrated, and where transfers of materials to an enclosed or semi-enclosed marine system have an overriding influence.

The concept of the **Large-Scale Marine Ecosystem** (LME) (Sherman and Alexander, 1986; Sherman *et al.*, 1990; Sherman and Solow, 1992) is most readily applicable to discrete shelf and ocean systems, where terrestrial inputs can be treated as extrinsic to the marine system as a whole. Sherman and Alexander (1986) defined LMEs as "extensive areas of ocean space of approximately 200 000 km² or greater characterized by distinct bathymetry, hydrography, productivity, and trophically dependent populations." LMEs may include areas of upwelling of nutrient-rich bottom water, or be major areas of retention of stratified shelf water, boundary current systems and other comparable oceanic systems.

All of the foregoing frameworks require the development of relevant marine scientific research, and monitoring of the marine environment, the resources, the fishing effort, catches and landings. Particular attention is therefore given to these topics.

Few fisheries can be sustainably developed in isolation, even at the local and national levels, because of the interconnectedness of the marine environment. Markets for fish and fish products have also become more and more regional or global. There is therefore a need for an international institutional and legal framework. This framework is defined, in practice, by major regional or global conferences and the conventions or formal declarations arising from them. The role of regional fishery commissions, and international organizations directly concerned with marine resources are particularly stressed in the UN Convention on the Law of the Sea. The pursuit of optimum harvesting and of the necessary research this entails are also stressed in Agenda 21 (see section 7.3 and Annex VII) which was the main result of the Conference on Environment and Development, in the pursuit of sustainable development of such resources. The effectiveness of the various fishery commissions and fishery conventions is also considered in section 7.5.

A major section (4) is devoted to the optimum harvesting of the resources; that is, their sustainable development which has long been the principal objective of fishery management. As noted, the pursuit of such development is considered to be through **responsible fishing** which means, essentially, the pursuit of rational fishery management

objectives in a broad sense - from consideration of the resource and its environment, to the processing and marketing of the fish; taking into account socio-economic, legal and administrative factors.

Opposing the achievement of rational fishery management objectives are the damaging effects of uncontrolled fishing, which is now being counteracted by FAO through the development of a Code for Responsible Fishing (see section 4.4).

First, the damaging effects of unrestrained fishing and fleet growth leading to over-capitalization of the fishing industry has resulted in less than optimum harvesting in many fisheries. A relatively small number of famous examples such as the cessation of fishing in the North Sea and recovery of North Sea plaice stocks after a period of 'biological repose' during the 2nd World War (noted by Beverton and Holt, 1957) are however often cited to show that stock recovery is possible once fishing pressure is relieved. Similar recoveries have also been shown by some seal populations once hunting has been brought under control. Other impacts of fishing such as the effects of trawling on the marine fauna and flora of the sea floor (e.g. Van Dolah *et al.*, 1991) are much more difficult to document, and are only now receiving much research attention.

Second, considerable difficulties remain in predicting the effects on the resources of short- (seasonal) and long-term (interannual to decadal) variations in the marine environment. There may also be a need to assess the relationship between these variations and the long-term global changes thought to be occurring, mainly as a result of the so-called "greenhouse" effect (see section 5.10).

Third, the damaging effects on the resources of other activities besides fisheries constitute a constraint on optimum harvesting, generally by preventing a fish stock from maximizing its production or by restricting the livable space the stock could occupy. Such activities are usually those of Man, such as: coastal construction and mining; disposal of coastal urban and industrial wastes and coastal aquaculture, and natural run-off from the land, directly or via rivers, and via atmospheric deposition, of nutrients, industrial effluents and pesticides (GESAMP, 1982; 83; 86; 90; 91) (Fig. 3).

Progressively more frequently, the accidental or intentional introduction of exotic species, including red tide species (White *et al.,* 1984) and larger organisms (Hallegraff and Maclean, 1989; Granelli *et al.*, 1990; Carlton, 1989 and Carlton and Geller, 1993), are having significant effects on marine systems. One notable example described recently, resulted from the introduction of a ctenophore, *Mnemiopsis leydei*, through ship ballast water into the Black Sea, where it has had a disastrous impact on pelagic fish stocks (GFCM, 1993).

Finally, the adoption of Integrated Coastal Zone Management (e.g. Chou *et al.*, 1991) may help provide a framework to limit fishing in coastal waters (wetlands, lagoons, estuaries, inshore/coastal seas to sustainable levels). In this case, the constraints on harvesting may be conducive to optimum harvesting, hence sustainable development. New options for sustainable harvesting of the resources should be considered in the context of responsible fishing and rational management, on a sound scientific basis (e.g. Chou *et al.*, 1991).

The interconnectedness of the marine environment and the indifference of marine organisms to man-made political boundaries (such as Exclusive Economic Zones: EEZs) demands an international and/or intergovernmental context for many aspects of fishery research, monitoring and management, and for sustainable development of marine resources

in general. Annex III provides some information on the international organizations, regional fishery commissions and conventions concerned with marine resources and their environment, giving the main lines along which they work, the difficulties they face and their requirements if they are to succeed in achieving sustainable development of marine resources.

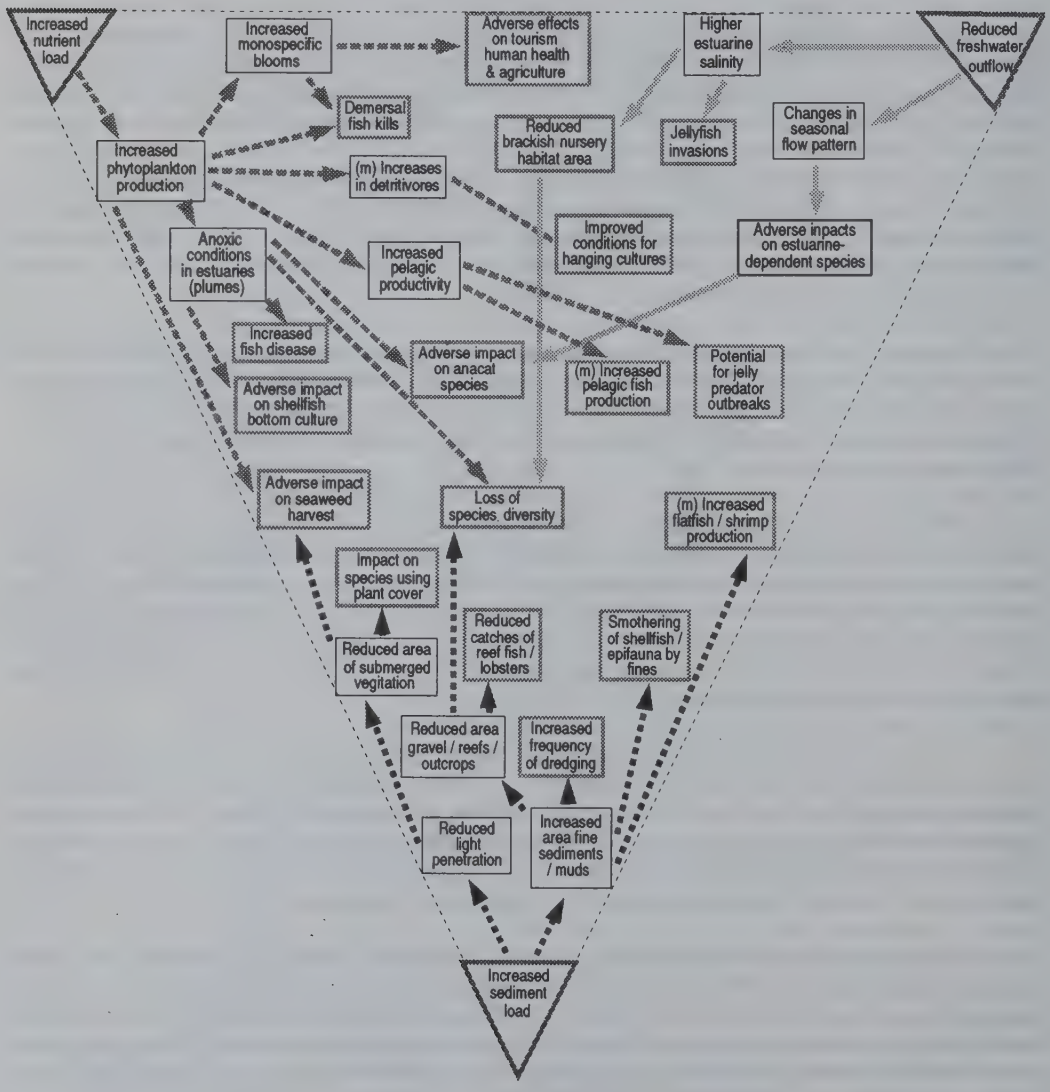

Increased nutrient load
Increased monospecific blooms
Adverse effects on tourism human health & agriculture
Higher estuarine salinity
Reduced freshwater outflow
Demersal fish kills
Reduced brackish nursery habitat area
Jellyfish invasions
Changes in seasonal flow pattern
Increased phytoplankton production
(m) Increases in detritivores
Improved conditions for hanging cultures
Adverse inpacts on estuarine-dependent species
Anoxic conditions in estuaries (plumes)
Increased pelagic productivity
Increased fish disease
Adverse impact on anacal species
(m) Increased pelagic fish production
Potential for jelly predator outbreaks
Adverse impact on shellfish bottom culture
Adverse impact on seaweed harvest
Loss of species diversity
(m) Increased flatfish / shrimp production
Impact on species using plant cover
Reduced catches of reef fish / lobsters
Smothering of shellfish / epifauna by fines
Reduced area of submerged vegitation
Reduced area gravel / reefs / outcrops
Increased frequency of dredging
Reduced light penetration
Increased area fine sediments / muds
Increased sediment load

**Figure 3.** Some synergistic effects on fisheries and marine ecosystems of 3 key results of human activities (from Caddy and Bakun, 1995).

A large number of priorities for action were proposed by FAO at UNCED for the consideration of these international organizations, regional fishery commissions and, above all, the Member States of these various organizations and commissions which are the signatories to the relevant conventions. These are briefly summarized following each section.

## 2. THE STATE OF LIVING MARINE RESOURCES AND THEIR ENVIRONMENT

The FAO periodically reviews the state of world fishery resources by FAO Statistical Area, separately for the marine resources, and for inland fisheries and aquaculture (FAO, 1992b, f). The most recent revisions were in 1994-95 (FAO, 1994b; 1995b, f). A parallel classification and much more general description is given in the following, that divides resources by major ecological zone.

### 2.1 NEARSHORE AND ESTUARINE RESOURCES AND THEIR ENVIRONMENT

The world population is expected to double in less than a century to some 10 billion people. UN figures (United Nations, 1985; 1994) suggest that 75% of these, with the highest rate of growth, will occupy a narrow strip some 60 km in width along the shores of the continents. In southeast Asia, about 65% of all major cities are already located along the coasts (United Nations, *op. cit.*). These figures illustrate the major and growing impact that human activities will be having on one of the most productive of global ecosystems: the shallow marine and brackish-water areas.

#### 2.1.1 Coastal Zones, Coastal Populations and Coastal Resources

The exploitation of coastal resources and habitats is a function of human population size and its level of socio-economic development. The continuing population growth, and its accelerated concentration in coastal zones and coastal urban centres (the so-called 'littoralization' of populations), implies intensive resource use and higher values for coastal land. At the same time, uncontrolled industrialization of coastal areas and the discharge of industrial by-products close to the coast is in conflict with recreational and living-resource uses, including fisheries and aquaculture (e.g. Pullin, 1991). All of these human impacts affect the marine ecosystem in unexpected ways; see e.g. Fig. 4). Poorly planned industrial developments, together with the consequences of high densities of transient and permanent human populations, as well as industrial-scale agriculture, have collectively lead to greatly increased adverse impacts on natural coastal systems throughout the world (UNEP, 1990a, b, 1994; Williamson, 1992).

Controlling coastal development and protecting habitats will require improved planning procedures, and will often involve painful social and political choices. The framework within which these choices must be made is commonly referred to as Integrated Coastal Area Management (ICAM: Clark, 1992). As noted, an alternative context for considering land-influenced events within coastal seas has been referred to as the Marine Catchment Basin (MCB) concept (Caddy, 1993a), which recognizes that human development of watersheds inland can also have a significant impact on coastal seas.

Such management must consider all uses of the coastal zone and take into account human activities, particularly in river basins (watersheds) discharging into coastal seas. The unrestrained use of rivers and estuaries for the discharge of nutrients and toxic compounds leads to significantly adverse impacts on critical marine habitats, but water extraction and, more generally, the regulation of rivers for navigation and flood prevention often have adverse effects on riverine fish (Welcomme, 1979) and diadromous species such as salmon, eels, and

shad, if not allowed for. The effect of inappropriate land management within the watershed on siltation of coastal and estuarine areas, with its adverse effects on coastal habitats, is another environmental factor due to human activities in the coastal zone, and falls at the interface between ecology and economics (Tisdel, 1982).

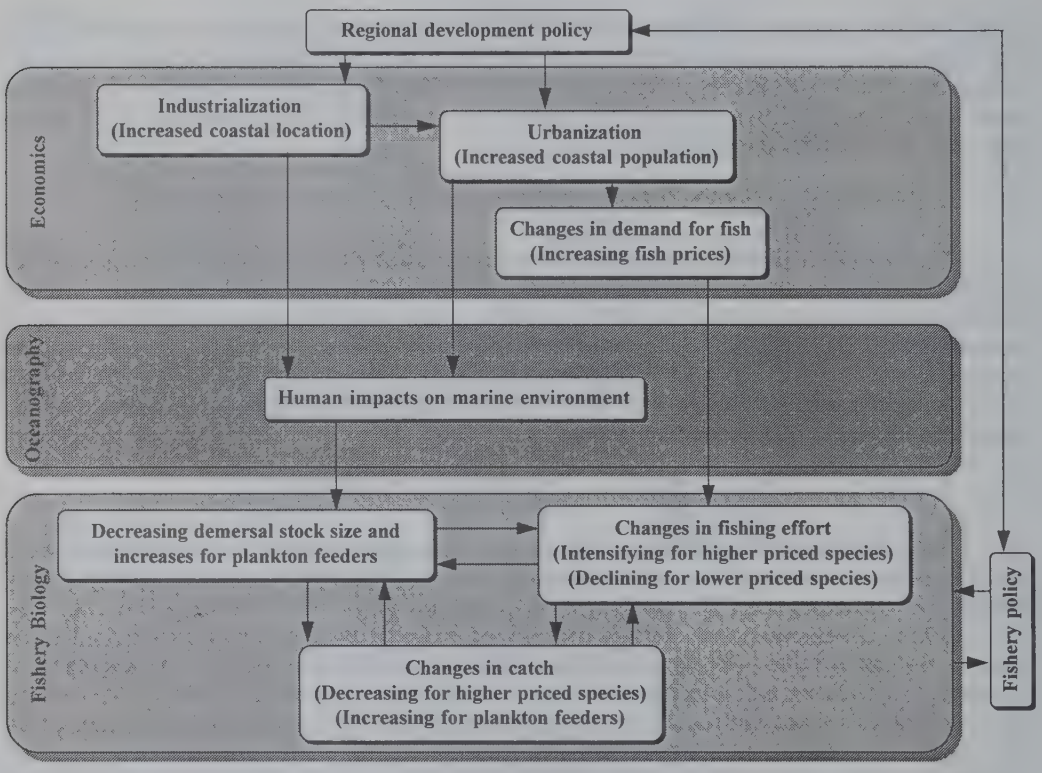



**Figure 4.** Schematic relationship between changes in human activities, and their current impact on the Environment and Fisheries of the Seto Inland Sea (from Tatara, 1991)

Soil erosion due to the removal of plant cover (e.g., deforestation) in watersheds, increases sediment loading of rivers and changes the seasonal cycle and amount of fresh-water run-off to coastal seas, as well as the levels of siltation (see e.g. Milliman, 1981; Milliman *et al.,* 1987; GESAMP, 1994). High riverine sediment loads adversely affect anadromous species such as salmon and sturgeon, and estuarine organisms such as oysters. It also has a serious negative impact on coastal coral reefs (Grigg and Dollar, 1988) and on aquatic vegetation which is often of key importance as fish habitat.

Exchanges across the land-water and air-water interfaces are obviously of particular importance for living marine resources (Martin *et al.*, 1982; Prospero, 1981; Liss and Slinn, 1983; Martin and Gordeev, 1986; GESAMP, 1987), and require the reconciliation of

sustainable development objectives in aquatic and terrestrial environments relevant to the nearshore and estuarine ecosystems.

Coastal wetlands and shallow nearshore waters play an important role as nursery areas for shrimp and fish (Boesch and Turner, 1984), and act, on the one hand, to moderate the impact of terrestrial activities on enclosed aquatic systems (e.g. GESAMP, 1994); activities commonly manifested as pulses of nutrients, suspended sediments and toxic materials entering coastal and inland seas. At the same time, wetlands and nearshore waters reduce the impact of the marine environment on terrestrial systems; this impact is manifested through such processes as storm surges, tsunamis and consequent coastal erosion (Murty, 1977, 1984; Pugh, 1987).(See Welcomme 1979). Such wetland areas are being lost at an alarming rate, world wide (e.g. Stroud, 1992).

New tools and approaches, remote sensing and Geographic Information Systems (GIS) in particular, make the investigation of cross-boundary processes more feasible than ever before (FAO, 1986a), and deserve wide promotion since they help to provide a sound, geographically based, foundation for decision-making in the management of a complex environment. Estuaries play a major role in the life cycle of many economically important fish species by providing breeding, nursery and feeding grounds from which about 95% of the world's marine production is currently obtained (Deegan and Day 1987; Turner 1987). The accelerated degradation of these critical habitats by indiscriminate trawling inshore, by land reclamation, drainage, coastal construction and mining and accompanying sediment deposition, threatens marine fisheries and wildlife and, in many areas, has already had destructive effects (ICES, 1992a; Campbell, 1993).

The role of contaminants in affecting marine ecosystems and their products has already aroused major concern. Thus, in GESAMP (1990) it is noted that:

> *"the major causes of immediate concern .... are coastal development and the attendant contamination of seafood, fouling of the seas by plastic litter, continued build-up of chlorinated hydrocarbons, especially in the tropics and subtropics, and accumulation of tar on beaches".*

The top priority for this key sector of the marine environment is to preserve current options and, in many cases, to rehabilitate degraded coastal systems essential to the early life cycles of many living marine resources that are exploited farther offshore, as adults. Estuarine fish production is often related to the characteristics of the estuary, including the water runoff pattern (e.g. Houde and Rutherford, 1993). The negative impacts of agricultural pesticide run-off on coastal wetlands and fisheries is now being more widely recognized, because of its particular impact on coastal low-salinity nursery areas (for shrimp larvae, for example), which can be decimated by "flash run-off" of flood water contaminated by pesticides following tropical storms.

So-called **eco-tourism** and **eco-recreation** place progressive emphasis on the persistence of unchanged and unexploited ecosystems, although even these activities are not sustainable in the face of unlimited access, as has been of concern to, for example, for the Australian Great Barrier Reef Marine Park Authority (GBRMPA, 1992/93). Conservation of marine habitat is progressively being associated with conservation of ecosystem complexity and biodiversity, and some habitats play a natural role in pollution abatement and the

mitigation of natural environmental impacts on coastal systems. The intangible benefits of conservation are receiving an increasingly higher profile as the public becomes more aware of impacts on marine wildlife (e.g., IUCN, UNEP and WWF, 1980). An upward evaluation of non-exploitive uses is to be expected.

### 2.1.2 Fisheries in Estuaries and along the Coastal Fringe

The coastal fringes of the world's oceans are the location of a high proportion of the production of living material directly or indirectly used by man (Marten and Polovina, 1982). Artisanal fishermen fishing nearshore coastal waters and shallow shelf seas represent over 90 percent of the employment possibilities in fisheries, and are an essential and conservative component of coastal communities. Estuarine and lagoon fisheries in particular, have a major socio economic importance (e.g. FAO, 1993e,j; Kapetsky, 1984; Lenanton and Potter, 1987; Willmann and Insull, 1993). Given a specific allocation of rights to a limited number of fishermen, artisanal fisheries are highly efficient in terms of quantity of fish produced per unit of energy input and per unit of capital invested: quality protein is produced for direct human consumption at affordable prices. Preservation of their rights to a reasonable proportion of fishery production, through the firm application of the juridical "polluter pays" principle, should be ensured within the framework of an appropriate management plan for the coastal environment and its living resources. Development and implementation of such a plan is one precondition for a good quality marine environment for the future. However, traditional systems of management are important, involving recognition of user rights for many indigenous people. These have, in some cases, broken down under the impact of foreign and industrial fishing, population influx to the coastal zone, and the competition from other users of the coastal zone, and there could be good reasons for their restoration (e.g., Doulman, 1993; Flood, 1994). A few systems such as mangrove forests play multiple roles in coastal environments (Fig. 5). The interface between freshwater and the marine environment is not only a dynamic one ecologically, but poses legal and institutional complexities (e.g. Hayton, 1990).

Estuarine fisheries, especially those for anadromous species, are particularly liable to uncontrolled water use, including the use of dams and barrages (e.g. Neu, 1975). These may also dramatically affect nutrient runoff into coastal seas, and have even had a dramatic effect on the salinity of some semi-enclosed seas (see Volovik *et al.*, 1993).

There are, of course, potential and actual conflicts of interest of coastal fishermen with agriculture and forestry (e.g., mangrove clearance and wetland drainage has occurred on a massive scale, especially in South America and Asia, for coastal rice growing, and shrimp and fish pond culture), but since fishermen generally do not hold property rights, they are rarely compensated for such land-based impacts on their livelihood (MacNae, 1974). Proper planning for such activities within a scheme of coastal zonation requires GIS systems for land and water use planning (Kapetsky *et al.*, 1987). Cash crops of rice, fish and other products almost inevitably replace the less intensive benefits which may arise in the future from maintaining the genetic diversity of complex habitats such as mangrove forests (Fig. 5), despite, for example, the latter's potential for production of new pharmaceuticals), and the less tangible and less enforceable common property benefits of preserving coastal vegetation for flood control, as ecological reserves and as nursery areas for coastal and shelf stocks of fish and shrimp (e.g. Turner, 1987; Mepham and Petr, 1987; Kapetsky, 1985). A systematic approach to conserving these fragile coastal ecosystems is needed (e.g. Hamilton and Snadeker, 1984) if the rich resource harvests they provide are to be conserved (McHugh, 1976).

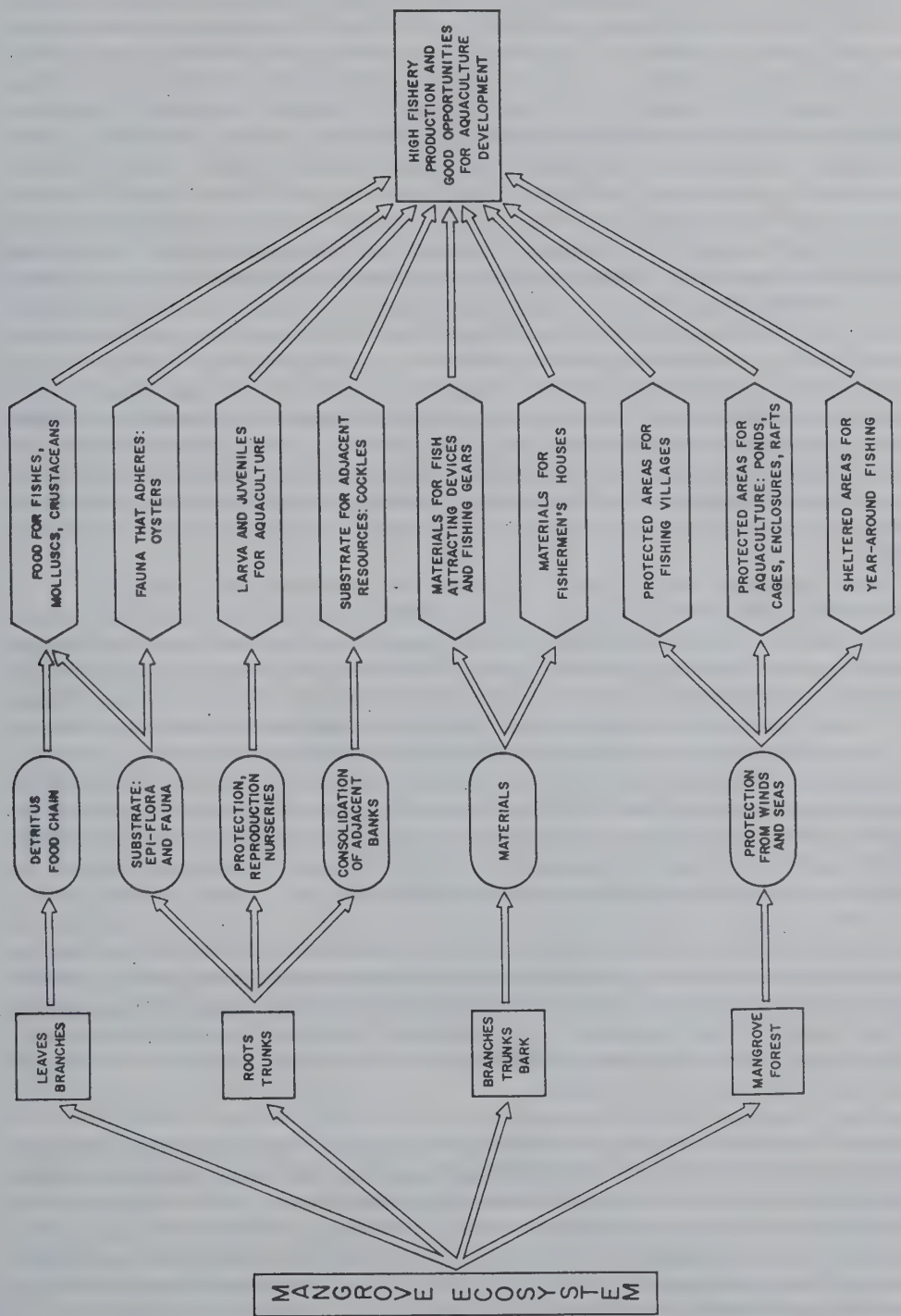

MANGROVE ECOSYSTEM
LEAVES BRANCHES
ROOTS TRUNKS
BRANCHES TRUNKS BARK
MANGROVE FOREST
DETRITUS FOOD CHAIN
SUBSTRATE: EPI-FLORA AND FAUNA
PROTECTION, REPRODUCTION NURSERIES
CONSOLIDATION OF ADJACENT BANKS
MATERIALS
PROTECTION FROM WINDS AND SEAS
FOOD FOR FISHES, MOLLUSCS, CRUSTACEANS
FAUNA THAT ADHERES: OYSTERS
LARVA AND JUVENILES FOR AQUACULTURE
SUBSTRATE FOR ADJACENT RESOURCES: COCKLES
MATERIALS FOR FISH ATTRACTING DEVICES AND FISHING GEARS
MATERIALS FOR FISHERMEN'S HOUSES
PROTECTED AREAS FOR FISHING VILLAGES
PROTECTED AREAS FOR AQUACULTURE: PONDS, CAGES, ENCLOSURES, RAFTS
SHELTERED AREAS FOR YEAR-AROUND FISHING
HIGH FISHERY PRODUCTION AND GOOD OPPORTUNITIES FOR AQUACULTURE DEVELOPMENT

**Figure 5.** Some functional relationship of mangrove with artisanal fisheries, fishery resources and aquaculture (after Kapetsky, 1985)

The uncontrolled use of large trees for building dug-out canoes was one direct and inefficient consequence of uncontrolled artisanal fishery development, but is only a very minor cause of the rapid clearance of coastal forests, particularly in the developing world. The demand for timber for building houses and boats, the clearing of coastal forests for coastal development and, in some places, for fuel and foreign exchange requirements, are among those factors that have contributed to deforestation of the coastal belt. This has had disastrous effects due to increased run-off of silt or sewage (Pastorok and Bilyard 1985) onto nearshore coral reefs and fish and shellfish nursery areas (Unesco, 1986; UNEP/IUCN, 1988) and can also lead to outbreaks of harmful organisms (e.g. Birkland, 1982).

These types of interaction are often outside the control of coastal communities, even though such communities may be best aware of the solution to these problems. This seems to call for specific devolution of decision-making capability to the local-government level. Evidently, such activities should take place within overall government guidelines provided by a multi-sectorial policy developed at the national level for coastal-zone development (e.g. Knox and Miyabara, 1984). Inshore fishing by large vessels, especially trawlers, competes with artisanal fishing, but if uncontrolled, will have an adverse effect on the nearshore marine environment, and may force artisanal fishermen into ever-shrinking areas of shallow water and to fish juvenile fish in coastal nursery areas (e.g. Caddy, 1993c). Under such circumstances some coastal fishermen may react by resorting to the use of damaging fishing methods such as bleach, poisons and dynamite, or the destructive harvesting of coral rock for construction. All of these activities impacting important fish habitat need to be rigidly controlled (Hoss and Thayer, 1994).

Increases in market demand without controls of fleet size; technical advances in gear, vessels and navigational and fish-finding equipment, as well as rapid population growth, have all contributed to increased fishing pressure and the breakdown of many traditional fishery management systems for which modern management mechanisms have not always been substituted. A key to rational resource use, hence to **sustainable development,** is the appropriate allocation of space and resources (FAO, 1986b), with direct community participation; and the adequate protection of resources from exploitation by outside interests. This may include the effects of inshore fishing by large trawlers outside the control of the local community, or the similarly uncontrolled effects of industrial or domestic pollution. Local authorities themselves may play an important role in the management and development of coastal fisheries and aquaculture (Barg and Wijkstrom, 1994).

Monitoring of environmental changes in coastal waters (e.g. McIntyre and Pearce, 1980), especially in estuaries and associated nearshore areas, deserves priority attention from coastal States, since not only are they biologically important loci along the land-water interface where many harmful materials in river water are discharged, but are also nursery areas for many valuable species, and areas where marine systems are fertilized from the land. Several broad generalizations can be made:

(1) The risks of environmental degradation and the consequent loss of economic potential, generally outweigh the future benefits offered by further uncontrolled exploitation of the living marine resources of nearshore and estuarine areas.

(2) Such areas are under the direct influence of a wide variety of terrestrial inputs, and their wellbeing and integrity is essential to most marine resources harvested farther offshore. Their importance is, by and large, even greater in tropical areas.

(3) In heavily populated coastal zones, many areas are already degraded and for **sustainable development** to offer a wide range of options, many coastal ecosystems will need to be rehabilitated.

(4) The legal aspects of the management and conservation of the freshwater-seawater interface have been little studied (Hayton, 1990) and estuaries are regularly subject to degradation as a result of this lack, in spite of the fact that many marine organisms feed, reproduce and have their nursery areas in estuaries.

### 2.1.3 Coastal Marine Aquaculture

At present, a relatively small proportion of the world aquatic production comes from **marine** aquaculture; most of this is centred on coastal waters, estuaries, lagoons, and semi-enclosed seas (FAO, 1992b). Essential to the sustained development of marine aquaculture, and to habitat enhancement measures such as the construction of artificial reefs, is the allocation of exclusive rights to users over the area of operation, and the protection of standing crops against the harmful effects of other users of the environment. Not all potential uses of the marine environment can be allowed to co-exist locally with marine aquaculture, and an appropriate legal regime must be developed (Van Houtte, 1994).

One of the serious current constraints on marine aquaculture, other than seaweed and bivalve culture (and a currently limited number of commercial fish species such as milkfish and mullet), is that most cultivated fish species are carnivorous and depend on animal-protein feeds (Tacon, 1994). This leads to economically important marine products commanding high market prices but does not necessarily contribute to food security. Aquaculture in 1988 was estimated to use some 10% of global supplies of fish meal as feed (Tacon, 1993).

In areas of high density of cultivation and reduced water exchange, aquaculture itself can provoke problems such as benthic enrichment and hypoxic water conditions. Excessive nutrient loadings from aquaculture may lead to local eutrophication in areas with low water exchange. In extreme cases red-tide outbreaks (GESAMP, 1991; Baden *et al.*, 1990) may result from discharge of nutrients (Ackefors and Enell, 1990). These have serious repercussions on aquaculture itself and on other sectors. In some tropical areas the extensive conversion of coastal wetlands and mangrove forest to fish and shrimp pond culture has significantly reduced the replenishment of natural shrimp populations which use these areas as nursery grounds (Chua, 1993; Phillips *et al.*, 1993). It has also eliminated areas of high biodiversity and had impacts on other functions of coastal wetlands (Chua, 1992; Chua, *et al.*, 1984; Saclauso, 1989; Barg, 1992). For example, it has compromised the role these coastal wetlands play in providing breeding and nursery grounds of fish and other species, and in protecting the coastal zone from storms, and as buffer zones reducing nutrient and silt run-off into the marine environment. To avoid adverse impacts, coastal aquaculture, among other coastal activities, should be planned within a framework of ICAM of Integrated Coastal Area Management (Clark, 1992; Barg, 1992; Chua, 1993).

### 2.1.4 Eutrophication and the Special Case of Phosphorus

Of particular concern and relevance to the integration of studies on the river basin and related coastal and inland seas, is the question of nutrient transfer from terrestrial to freshwater and marine systems (Howarth, 1993) and, most particularly, the largely one-way flux of phosphorus from terrestrial ecosystems to the aquatic environment (Fig. 6). The levels of nutrient flux across the level-water boundary in many countries are historically a function of drainage and land use (Lehtonen and Hilden, 1980). In its various forms, phosphorus is a key element, potentially economically limiting for intensive agriculture, an important ocean component of domestic and industrial wastes, and for which, unlike nitrogenous compounds, environmental transport is largely aquatic. Excess quantities of both elements in runoff can have negative influences on the fisheries of semi-enclosed water bodies (Lehtonen and Hilden, 1980).

Human activities are estimated to have caused an approximately five-fold increase in river inputs of nitrogen to the oceans, and, for phosphorus, about four-fold, as judged by the well-documented history of one European river, the Rhine (Lelek, 1989). The annual total for input of phosphorus to the oceans has been estimated to be about 0.59 Tmol (1 teramole of phosphorus is equivalent to 31 million tons of phosphorus). This is made up of a long-term background level of some 0.15 Tmol in river outflow, 0.32 Tmol due to soil leaching and land erosion, and 0.12 Tmol due to waste discharges from human populations, industry and fertilizers (van Bennekom and Salomons, 1981). Not all phosphorus in suspension is available to marine food chains; as for silt, metals and many toxic compounds, much is precipitated out in estuarine and marine sediments. The figures given above for run-off of phosphorus into the oceans may be contrasted with those given by the same authors for the world production of 0.37 Tmol of phosphate fertilizer in 1975, and of 0.026 Tmol for detergent phosphate. Although all of these figures are very approximate, it seems that mining of phosphorus is only replacing some 70% of that lost in freshwater run-off to the oceans annually (FAO, 1991c).

Much scientific debate has focussed on whether primary production in aquatic systems is limited by phosphorus or by other nutrients or trace elements (e.g. Ursin and Andersen, 1991). Other elements may be limiting in particular circumstances (for example, iron has been shown to be limiting in some tropical offshore waters (Martin *et al.,* 1989; Fuhrman and Capone, 1991) and silicon levels in river outflows may be reduced by pollution: (Doering *et al.*, 1989).

Nitrogen is usually limiting in coastal waters in north-temperate latitudes, and phosphorus may be limiting in lakes and in tropical seas (see Mann and Lazier 1991). However, the precedent for considering phosphorus as a measure of biological production (e.g. Andersen and Ursin, 1977), and with carbon, as a 'marker' for flows of energy throughout the marine food web appears well established, since unlike nitrogen, it remains within the water and sediments. Other elements than phosphorus and nitrogen, such as silicon and iron, also deserve special attention from terrestrial and aquatic ecologists and from fishery and agricultural research institutes. The practical measures to control the effects of run-off relate largely to actions on land: to improve land use strategies; to encourage riparian control of run-off into waterways; and to improve effluent treatment and discharge practices. The overall productivity of coastal and inland seas is normally increased by nutrient run-off, but above a limited level of runoff, it is very doubtful that the net benefit to fisheries is positive.

Unlike nitrogen, phosphorus compounds are not broken down to the gaseous inactive element, and a large proportion of phosphorus in run-off is stored in oxygenated sediments. Although partially inactivated, it may be more easily recycled from deoxygenated bottom sediments back into the pelagic food web (including fish: Kraft, 1992), and contribute once again to eutrophication. From the standpoint of agriculture this loss from terrestrial systems is surely not beneficial, and one cause of unnecessarily high fertilizer budgets for plant husbandry on land is that "downstream" aquatic impacts are not entered in the cost/benefit calculation.

A recent study of marine food webs leading to fish production (Pauly and Christensen, 1995) found surprisingly high rates of utilizations of 24-35% of primary production in freshwater and shelf (marine) ecosystems, and not surprisingly, much lower rates for open ocean systems. The first of these sets of figures suggests that nutrients should be limiting to fish production, and illustrates how close mankind is to fully exploiting all of the biological resources of coastal and shelf areas.

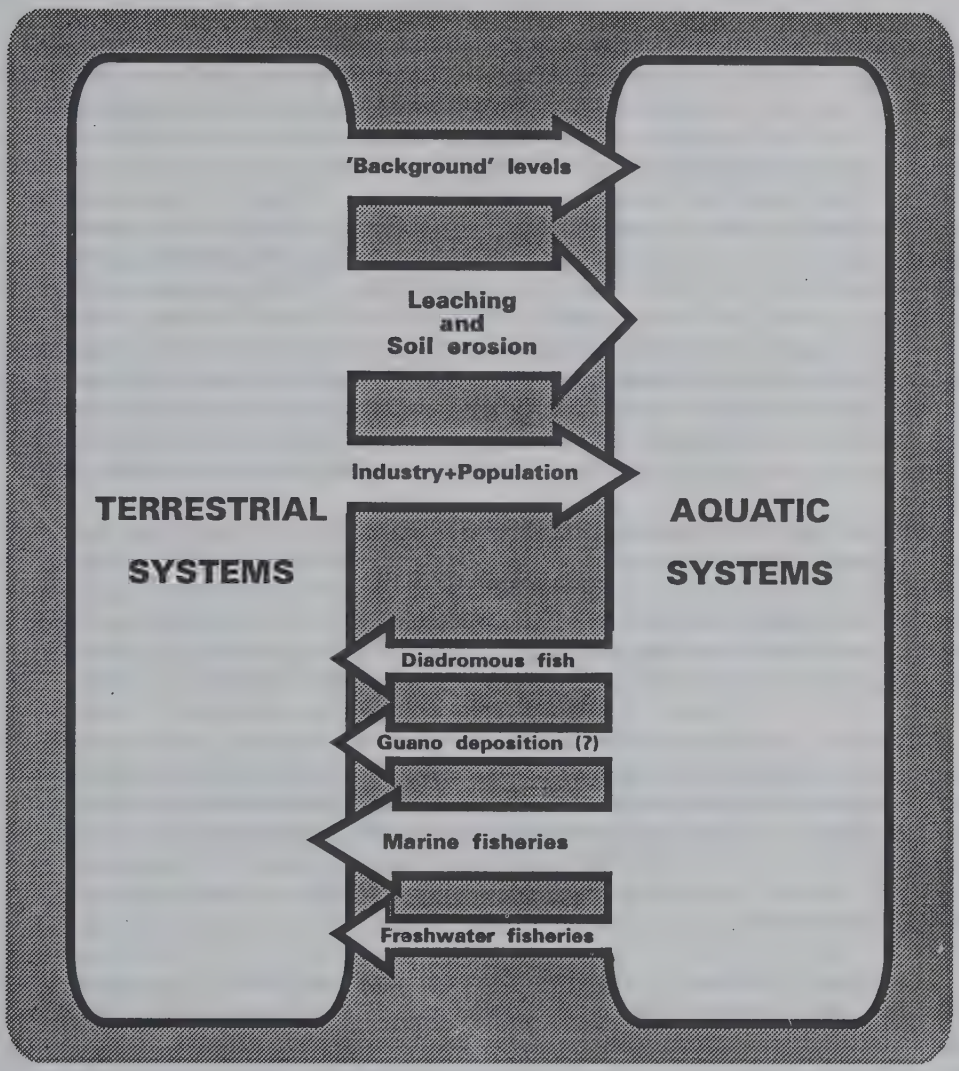



**Figure 6.** Diagrammatic representation of the interchange of phosphorous between terrestrial and aquatic systems. Width of arrows roughly indicate relative rates of flow (although the 3 lowest rates of flow are exaggerated for ease of illustration).

### 2.1.5 Other Ocean-Atmospheric Linkages

Concern has also been expressed over the possible reduction of marine biomass due to the effects of toxic waste discharge into the oceans, as well as to the growing ozone hole in the atmosphere; this biomass, and the oceans themselves, act as "sinks" for carbon, and hence reduces the free carbon dioxide and methane in the atmosphere thus limiting the so-called "greenhouse" effect (Sarmiento *et al.*, 1988). An alternative effect might follow from nutrient enrichment if a large proportion of organic material produced as a result of eutrophication enters carbon "sinks" such as bottom sediments underlying anoxic water masses; besides the effect this storage of material containing carbon in bottom sediments might have on the benthic and demersal resources of an area.

Many marine algae, as well as some sea grasses and salt-marsh grasses, produce dimethylsulphonium compounds. Dimethylsulphonium propionate (DMSP), which is one of the principal metabolites in many benthic and planktonic marine algae, is broken down enzymatically to produce dimethylsulphide (DMS) and acrylic acid (Andreae, 1989). Although production is variable according to region and season of sampling, eutrophication, by favouring algal growth, may favour production of DMS, which may be lost to the atmosphere where the DMS is oxidized to such products as methane sulphonate, sulphur dioxide and sulphate; such compounds play an important role in the formation of acid rain, while DMS itself is an important source of cloud-condensation nuclei (Holligan and Kirst, 1989).

Methane may be produced in a number of ways in the marine environment: from reducing bottom sediments, as the result of hydrocarbon extraction by Man from the sea bed; and *in situ* in the water column, either by methane-forming bacteria in reducing micro-environments or by algal metabolism; eutrophication can be expected to play a role in this flux of methane between the sea and the atmosphere. Some of this methane, which is relatively stable in the marine environment, is released into the marine atmosphere (Liss, 1989).

The effects of the ozone hole on marine resources has already begun to be of concern, particularly with respect to the effects of increased intensity of ultraviolet light on eggs and larvae of fish and other organisms in the surface areas of the ocean (e.g. Hunter *et al.*, 1979), and experiments in Antarctic Seas have begun to investigate this effect (Gieskes and Kraay, 1990).

### 2.1.6 Proposed Actions

The following actions (in **boldface**), in some cases supported by complementary text (in lightface), were proposed in FAO (1991c) with respect to **sustainable development** of nearshore and estuarine areas:

(i) **Classification and mapping of nearshore and estuarine areas in a Geographical Information System (GIS), showing their current multiple usage.**

(ii) **Establishment of an inventory of particularly sensitive areas or critical habitats, which should be given special recognition in national legislation.**

(iii) **The conservation of coastal wetlands and other areas of marine vegetation, as critical habitats for many commercial and non-commercial species, and as a means of maintaining biodiversity.**

(iv) **Classification of proposed new developments and their consideration for approval only in the context of an Integrated Coastal Area Management (ICAM) Plan, according to an assigned priority of use, or mix of uses, with local inputs which can be shown to co-exist without damaging mutual impacts.**

(v) **The formal control of access to coastal resources and environments, with mechanisms ranging from seasonal and permanent closure of areas to exploitation, to assignment of specific and carefully delimited user-rights to individuals or coastal communities whose livelihoods depend on the health of these resources.**

(vi) **Definition and establishment of user-rights and responsibilities with respect to living marine resources, whether for harvesting or recreational purposes, including the right to legal redress in the event of adverse impacts on these resources and environments by third parties, and, if appropriate, a mechanism for transfer of user rights between bona fide users.**

(vii) **The setting up of a management and consultative framework for users of the coastal resource and environment, within a legal context, subject to government guidelines.** *For larger countries, it may be appropriate within these national guidelines that rights and responsibilities be explicitly devolved to regional and local levels, and include mechanisms for the resolution of conflicts of interest.*

(viii) **Severely restricted and controlled use of inshore waters and incoming rivers as points of dumping or discharge of unwanted materials.** *Routes whereby airborne effluents enter the coastal marine environment also need to be documented. Where these effects can be reduced, appropriate treatment and disposal mechanisms should be introduced. Legislation needs to take into account the fact that some materials placed in coastal waters (e.g., artificial reefs and other structures) may enhance fish production or discourage inshore trawling in prohibited areas.*

(ix) **Governmental recognition and addressing of the impact on the marine resources and environment of human activities outside the immediate marine context is called for, and there is the need for specifically addressing these impacts, increasing co-operation and exchange of information between those national entities, governmental and private, responsible for fisheries, agriculture, water resources, forestry, tourism, and with such sectors as coastal urban planning, industry, transportation and other land and sea users.**

(x) **Explicit recognition is needed, with respect to estuarine, anadromous and catadromous resources, of the impact of land- and water-use practices throughout each marine catchment basin (MCB).** *Engineering modifications for controlling water flow should require a prior assessment of their downstream effects.*

(xi) **The separation and, to the extent possible, individual treatment of discharges of biodegradable organic material and nutrients, and of non-biodegradable and toxic wastes, into the aquatic and marine environments, should be allowed for.** *The discharge of toxic wastes into the aquatic environment directly, or via the atmosphere, should be forbidden. The discharge of biodegradable materials should be closely tied to the assimilative capacity of the receiving environment and to the relevant Integrated Coastal Area Management scheme.*

(xii) **Reduction in the loss of nutrients and topsoil to aquatic systems requires the adoption of riparian measures along watercourses, by evaluating the role of flood plains, by preventing deforestation of the upper reaches of MCBs, and by conservation of wetlands in deltas.** *These nutrient losses represent a high cost to terrestrial ecosystems, agriculture and forestry, and need to be specifically addressed when considering human water use and modifications to watercourses.*

(xiii) **Recognition that the normal estuarine or lagunar fauna and flora, flourishing runs of diadromous fishes, and coastal wetlands and wildlife, are the best indicators of the health of the aquatic system as a whole.** *The contrary situation implies human health problems, contamination of water, high costs of environmental rehabilitation, and the loss of living resources for food and recreation.*

## 2.2 COASTAL AND SHELF-SEA RESOURCES AND THEIR ENVIRONMENT

### 2.2.1 The Exploitation of Shelf Resources

Roughly 86% of the total world aquatic production of finfish and invertebrates, estimated by FAO at 98.3 million tons in 1990, came from the sea, and about 95% of this marine catch came from Exclusive Economic Zones (FAO, 1994c, 1995c,e). In the tropics, most of the marine catch is taken over the continental shelf close to the coast (ICLARM, 1992). The maximum production obtainable by capture fisheries on traditional species is considered to be around 100 million tons (FAO, 1993b; 1994b) but it is clear from recent studies that sustaining this level of production will only be possible, if at all, with proper management to avoid serious impacts on conventional resources and their biotic environment and coastal ecosystems (Pauly and Christensen, 1995). Clearly, the maintenance of marine food supply at recent levels requires strategies for sustainable development of fisheries (e.g. FAO, 1991d)

As a broad generalization, coastal marine resources may be considered fully exploited or overfished practically everywhere, especially those with high commercial value (shrimps, lobsters, crabs, large fish species etc.), and the main potential mechanism to attain **sustainable development** is through improved management of these resources, with the principal management objective being to attain sustainable use while preventing stock declines. The classical 'Reference Point' for sustainable use was the 'Maximum Sustainable Yield' (MSY). More recently, pursuing MSY as a Management Target has been shown to be a 'high risk'strategy (e.g. Larkin, 1977; Sissenwine, 1978) as well as being in excess of safe biological (Caddy and Mahon, 1995) and economic optima (Clark, 1976).

#### 2.2.1.1 Shelf upwelling systems

Wide variations in the abundance of fish stocks are particularly noteworthy in upwelling areas which contain very abundant pelagic resources and contribute between one third and one half of the world's catch (e.g. Flores, 1989). The over-exploitation of such stocks with a high natural variability has contributed to population collapses, although, as illustrated by the Peruvian anchovy (Flores, *op. cit.*) and the small pelagic fish stocks of the Chilean, NW African, Namibian and Californian areas, (Kawasaki, 1983) these resources show wide, and often close to synchronous changes in abundance (Lluch Belder *et al.*, 1992) (Fig. 7), in which long term climatic changes associated with the ENSO (El Niño - Southern Oscillation) phenomenon (Bakun, in press), rather than overfishing, appear to play the key role (Bakun, 1993). A high level of natural variation must be allowed for, therefore, in management plans for the fishery resources of these areas. Upwelling is tied to local wind regimes which, in turn, tend to be tied to large-scale changes in the coupled atmospheric-

oceanic systems. The dominant global phenomena here are ENSO events (Bakun, 1992), the major mode of short-term climatic changes throughout the world (e.g. Kiladis and Diaz, 1989), with important interannual and interdecadal time scales (Bakun and Parrish, 1980).

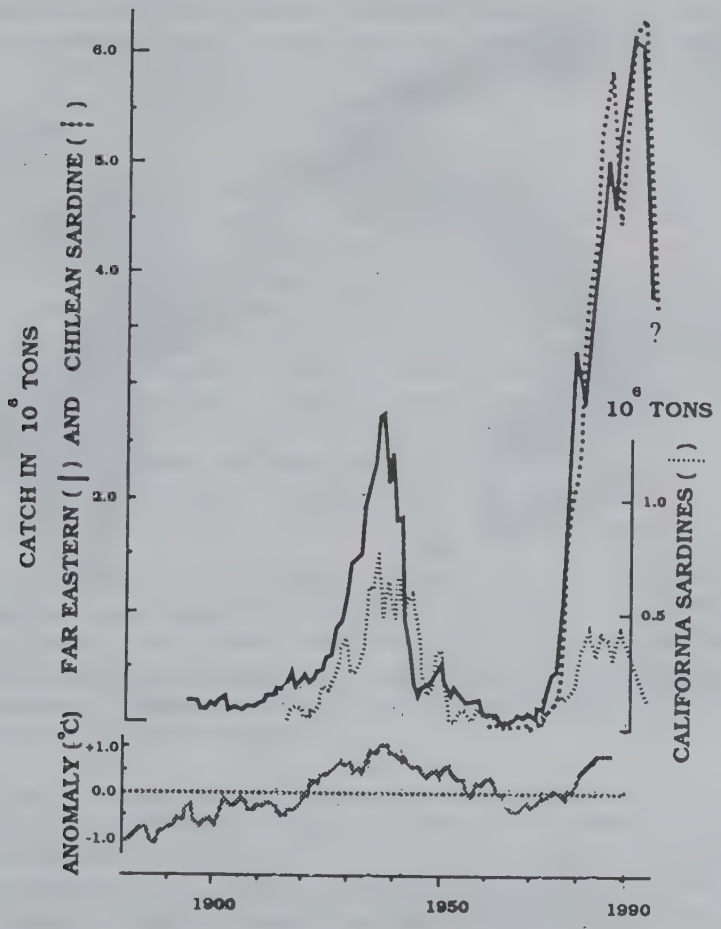



**Figure 7.** Landing trends for three widely separated Pacific ocean fisheries for the sardine *Sardinops* spp. showing apparent scheduling through basin-wide environmental process illustrated here together with the North Pacific temperature anomaly (from Sharp and McLain, 1993 with date from Kawasaki).

The geographical distribution of major sources of nutrients for coastal fisheries are shown in Fig. 6 and the accompanying table from Caddy and Bakun (1994).

2.2.1.2 Shelf areas fertilized by land run-off and/or tidal mixing

Shelf areas make up a significant proportion of productive fishery systems: the North Sea, the Bay of Bengal and the Yellow Sea are good examples (Caddy and Bakun, 1994). Such systems have predominant characteristics which determine the main source of nutrients and hence their productivity. Caddy and Bakun (1994) distinguished two typical sources of nutrients for shelf food webs in addition to upwelling: these are tidal mixing (characteristic inter alia of the N.W. Pacific, Patagonian and North Sea Shelves, Mann and Lazier, 1991); and land-based runoff (e.g. South China Sea, Gulf of Mexico and Gulf of Guinea) (Figure 8).

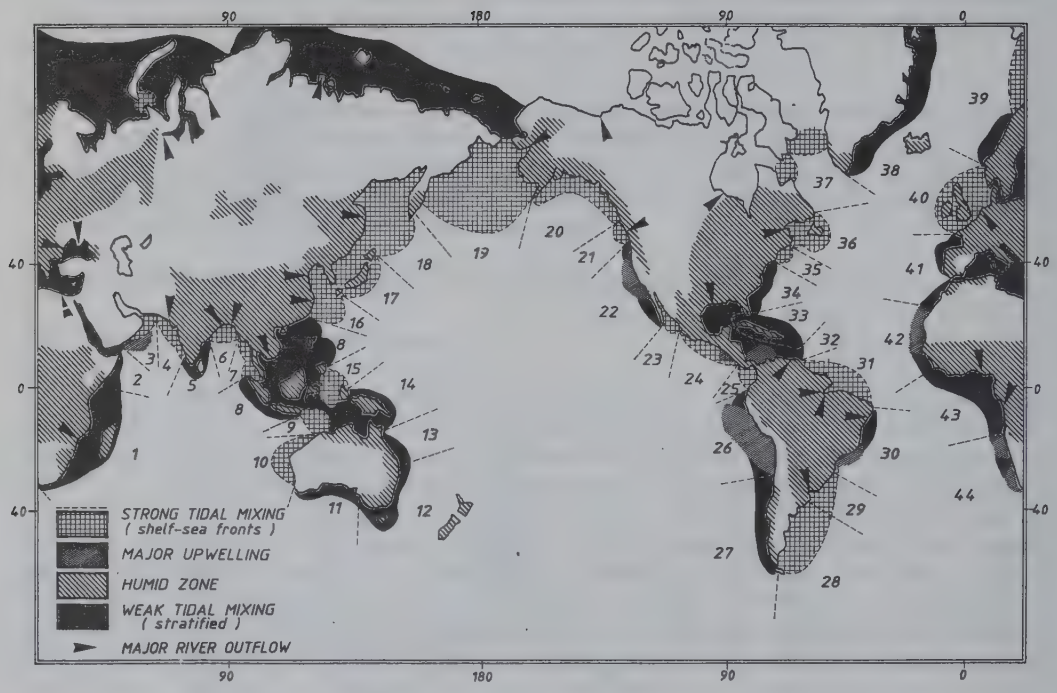



**Figure 8.** Composite map showing areas of predominant nutrient sources for coastal fishery production (Caddy and Bakun, 1994).

As for semi-enclosed seas, shelf areas merit special attention in developing fishery management plans and in designing environmental monitoring systems. Specific problems and potential benefits of such management and monitoring are discussed in some detail in sections 2.1.4, above, and 2.2.2, below.

Features known as "shelf-sea-fronts" often appear on continental shelves where substantial mixing of the water column by tides carries nutrients up from deeper water where they become available to support photosynthesis. Such areas (e.g. the North Sea, North Pacific, Patagonian Shelf) are typically rich fishing areas (Caddy and Bakun, 1994).

### 2.2.1.3 Coral reefs

Coral reefs are characterized by many specialized species each with a particular food preference and/or mode of feeding. These species and habits have evolved over long periods of geological time within a very stable environment and, although the overall biological

production of coral reefs is surprisingly high for a nutrient-poor environment (Jones and Endean, 1973; ICLARM, 1992), a significant proportion of the nutrients is bound up in the biotic components and only slowly replenished once the biota have been harvested (Jones and Endean, *op.cit.*). This is in contrast to the less complex and "younger" ecosystems typical of upwelling areas and the shelf seas of northern latitudes, which are characterized by significant quantities of free nutrients during certain seasons, wide fluctuations in abundance, and communities dominated by species with broad, flexible feeding patterns, which are relatively resistant to intensive fishing (Ursin, 1982).

Coral-reef communities have not developed the ability to react in a flexible manner to unusual stress such as heavy human exploitation and more than light nutrient or sediment inputs (Hughes, 1994; UNEP/IUCN, 1988; Johannes, 1975). There is evidence that many such communities have been irreversibly degraded by human activities, their fish communities modified, and the living substrate replaced by much less complex systems based on algae growing on the former dead coral heads, and disturbed coral ecosystems have been attacked by predators such as crown-of-thorns starfish (UNEP/IUCN, *op. cit.*). The problems of preserving and restoring production coral reefs will have to be tackled at the community level; by removing damaging influences; in part by restoring traditional harvesting rights (e.g. Doulman, 1993; Flood, 1994) or other means of restricting access to reefs and their resources. Coral-reef systems are extremely sensitive to environmental change, and perhaps more so than for most other marine ecosystems (Grassle *et al.*, 1990), their biodiversity is adversely affected by turbidity and nutrients.

In addition to the very real problems faced by reef resources such as the negative effects of overfishing, inappropriate and damaging fishing methods, reef mining, siltation and nutrient run-off, of more recent concern is the "bleaching" of shallow reefs (UNEP/IUCN, *op. cit.*). This may be an indication of deteriorating conditions such as destruction of the ozone layer with a subsequent increased exposure to ultraviolet radiation. Such effects risk being worsened in the event of climate change.

Areas of pristine coral reef have a major recreational potential under conditions of controlled access to commercial fishermen (Tilmant, 1987; GBRMPA, 1992/93; Jones, 1994)), and this potential grows in value as more reefs are degraded around the world as a result of inappropriate usage. It may be necessary to decide between exploitive and non-exploitive use for certain areas; for the latter, resource exploitation may need to be reduced to low levels, given that this detracts from visual appreciation of the unique biodiversity of these habitats (UNEP/IUCN, 1988): a new source of economic wealth through "ecotourism".

### 2.2.2 Environmental Impacts on Shelf-Sea Resources

It is no longer possible to make the assumption that the only way that Man can influence the state of shelf resources is by the application of classical fishery regulatory mechanisms, as by imposing size limits or quotas, by seasonal closure of fishing areas (Garcia and Demetropoulos, 1986), or by controlling fishing effort (Caddy 1993c, 1993c). Human activities are influencing the renewable resources of shelf areas directly and indirectly, in other ways, and this has been a subject of debate at a number of FAO conferences in recent years (e.g. FAO, 1991a).

In general, the surface waters of the open oceans are characterized by a serious shortage of nutrients, and the theory of nutrients in the marine environment is concerned with deciding which chemical element is limiting on phytoplankton growth (see Gerlach, 1988). In many areas of the world's oceans, water masses along the "open" coast may retain their identity for considerable periods of time, so their resources may be presumed to be

particularly susceptible to "land effects", especially those due to run-off of materials (Caddy and Bakun, 1994). Figure 1 shows one classification of such habitats on the basis of major sources of nutrients to coastal waters. Some examples in temperate seas are the eastern North Sea, the Bering Sea, the Gulf of St. Lawrence and Scotian Shelf, the Sea of Japan and the Patagonian Shelf (Caddy and Bakun, *op. cit.*). In the tropics, areas receiving and retaining run-off from large rivers are those most likely to be affected, such as the Bay of Bengal, the South China Sea, and the Gulf of Guinea. These marine areas are heavily influenced by the nutrients and large sediment loads discharged into coastal seas. This is particularly the case for Asian rivers with their long histories of watershed development, but is also a steadily augmenting process in many estuaries throughout the World (Meade, 1981). Coastal water masses receiving river discharges in open sea areas would appear to merit the same priority attention for environmental monitoring as semi-enclosed seas (e.g. Drinkwater, 1986).

There have been a growing number of human uses of shelf areas that will have to be reconciled with sustainable development of marine resources. Potential conflicts between these two general objectives have so far been recorded in the following areas:

(1) dumping of chemical wastes, sewage sludge and fly ash in shelf areas, and anoxic conditions caused by eutrophication, have both been implicated in the increased incidence of diseases and skin cancers of some bottom fish in the North Sea (Dethlefsen, 1980);

(2) extraction of sand and gravel from the sea bed affects many benthic species and damages spawning grounds of some fish (ICES, 1992a; Campbell, 1993), and can have particularly negative impacts on beaches; effects are, however, limited in time and space and can be reduced by careful planning and attention to operational procedures and appropriate zonation under ICAM;

(3) at-sea oil and gas extraction rigs and pipelines may cause loss of fishing gear to trawlers, but may also act as refuges for heavily fished bottom fish (e.g. Dugas *et al.*, 1979; Reggio, 1987).

In general, these effects, with the possible exception of local impacts of heavy oil spills, tend to be of less concern, and have less impact on marine systems than do other effects resulting from human activities on land. As mentioned earlier, the most serious impacts show up in nearshore waters and semi-enclosed seas. Any disposal of effluents at sea should take into account conditions at the point of discharge, current patterns, and the zoning by use of the affected areas. The negative effects of coastal development on the marine environment now extends to many developing countries in the tropics (Linden, 1990).

As a priority, fishery and coastal zone resources and aquatic habitats that are not yet degraded need to be brought within effective management regimes. Rehabilitation of resources is a more costly way of achieving **sustainable development** than timely action. Coastal marine parks or protected areas (e.g. Dixon and Sherman, 1990) may contribute to revenues from non-exploited use of resources, as well as preserving important stock components (e.g. for spawning). In general, low cost improvements in position-fixing (both of locations and fishing vessels), including satellite navigation systems, promise to make zonations and season-area closure, much more effective management systems than formerly was the case, even in offshore waters.

### 2.2.3 Resource Enhancement Measures

The application of high technology to increasing marine productivity of shelf and open-ocean systems is still in the planning stage and will require significant investment that currently is being overexpended in maintaining excess fleet capacity. As for inshore aquaculture, the exploitation of resource enhancement measures also depends on more specific allocation of user-rights, and this is probably also the context for the futuristic vision of "offshore communities" or "floating cities", which are already in the design phase (Simard, 1986). It is perhaps not a coincidence that major developments in this direction have arisen in Japan, where a well-developed system of user rights has long been established (Simard, 1986; Ruddle, 1987).

Three main areas of application of technology with potential for realization early in the next century, seem worth mentioning however:

(1) Induced upwelling of cold, nutrient-rich bottom water into warm nutrient-poor surface water has been proposed as a potential non-polluting energy source (OTEC) and would incidentally increase productivity around for example, deep-water islands; induced upwelling could also be associated with food production of wild or cultivated species.

(2) Artificial reefs, if installed on a large enough scale (of the order of tens to hundreds of hectares), would increase productivity of valuable benthic and demersal species and provide a focus for coastal community development in the context of exclusive user rights (e.g. Christie, 1982; D'Itri, 1985; IPFC, 1991;). Experience with this type of application is to be found in Japan (Simard, *op. cit.*).

(3) The application of high technology to support the transfer of aquaculture technology to offshore areas where natural or artificially enhanced productivity can be maintained is a possibility that deserves further research.

### 2.2.4 Management of Coastal and Shelf-Sea Fisheries

In many parts of the world, traditional systems of management operate (e.g. IPFC, 1994). Here, fishermen's guilds or close-knit fishing communities have restricted access by outsiders to local marine resources (e.g. Berkes, 1985; Berkes *et al.*, 1993; Flood, 1994). In these systems fishing opportunities are shared by participants and a degree of resource conservation has often been achieved.

The development of long-range fleets in the 1960s and 1970s, and major technical innovations in gear, vessels and handling and storage of the catch, was closely followed by the application of similar efficient harvesting methods in coastal fisheries in many areas. Both trends have tended to disrupt traditional patterns of resource use and placed greater pressure on resources, without modern management systems being introduced as a framework for limited access to living marine resources. The emphasis on industrial fisheries development over the last 40 years has perhaps understated the importance, cost-effectiveness and socio-economic importance of managing small scale fleets in light of their role in food production (Pollnac and Morrissey, 1982; Panaystou, 1982).

In fact, most shelf fisheries throughout the world still operate under open-access conditions, which implies that they are being harvested under conditions of high exploitation and low return on investment (World Bank, 1992; FAO 1992e). The effectiveness of current strategies to achieve **sustainable development** of coastal and shelf resources under open access is debatable and new, and if necessary experimental approaches, need to be tested

and evaluated. At the same time, high pressures in the tropical coastal zone and the consequent high levels of exploitation (e.g. Pauly, 1979b) lead to use of fisheries as the "employment of last resort" for economically disadvantaged persons displaced from agricultural, industrial or urban communities. This makes the necessary control of access a politically delicate matter.

Even in the developed world the management of fisheries has run into difficulties which can also be traced to a lack of action in restricting access to natural resources that have a limited potential for self reproduction. Systems for controlling fishing effort indirectly through the use of catch quotas or Total Allowable Catches (TACs) have been running into increasing difficulties for a combination of reasons (Beddington and May 1977; Sissenwine 1978, FAO 1993b, 1994b, 1995e), the most important of which come down to the difficulty of reducing access to a reasonable number of participants wherever historical access rights have been established. Some of these difficulties are aggravated by over-optimistic interpretation of catch and research data as to the state of stocks, by misreporting of catches, and by the inability to forecast true levels of abundance. In the case of unobserved stock declines, fixed TACs lead to overfishing by a quota that, under constant numbers of new recruits added annually, would correspond to moderate levels of fishing. The use of the concept of Maximum Sustainable Yield (see section 4.1) under conditions of high uncertainty about stock abundance and interactions between fleets and stocks, can also contribute to accidental overfishing and the instability of resources (Garcia *et al.*, 1986; FAO, 1992e).

Inasmuch as there is no simple solution to these difficulties, strict control of the number of fishing licences and the fishing power of individual vessels (e.g. Robson, 1966) appear essential preconditions if a workable management is to be found. The removal of open-access conditions for all fisheries, national and international, the payment of user fees, the establishment of maximum allowable effort levels, allocation schemes, and systems of transmitting user rights between individuals, can also be expected to contribute to the sustainability of fisheries (Gordon, 1954; Hardin, 1968; Berkes, 1985). Otherwise, costly redeployment schemes for fishermen must be sought in other sectors of the coastal economy, including aquaculture.

Apart from the pressures for employment in shelf-sea fisheries, long considered a marginal and uncontrolled sector of the national economy, the fact that real landings have reached a plateau and due to poor management have even declined in many cases, means that a constant level of supply with a steadily increasing demand has the effect of increasing real prices for fish (FAO, 1992e). This then generates pressure for increased rates of fishing on these resources and, in turn, leads inevitably to a decline in landings.

The UN Convention on the Law of the Sea (Annex IV), by stipulating the rights and obligations of coastal States in extending their jurisdiction over fisheries, removed the condition of free and open access that the distant-water fleets formerly operated under on most continental shelves within 200 miles of the coast. Subsequently, many coastal States internalized the problem of effort control, allowing an increase in fishing effort under the free and open-access conditions prevailing within national maritime jurisdictions (e.g., FAO, 1993b). This occurred because no specific rights were assigned to national harvesters and, in many cases, through excessive use of inappropriate subsidy schemes, this led to excessive fishing effort and further deterioration of the national resource base. Special cases are the highly migratory resources and those straddling stocks lying across 200-mile EEZ boundaries with international waters. Here access is effectively uncontrolled beyond 200 miles, and the prospects for joint management of the stock are even more problematical, given that a unit

stock must be managed in a co-ordinated fashion based on information on catches throughout its range. These latter problems are among the matters currently being discussed by the United Nations Conference on Straddling Fish Species Stocks and Highly Migratory Stocks (FAO, 1994) and in development of the FAO Code of Conduct for Responsible Fisheries.

Among other possible mechanisms for controlling fishing effort are the implementation of fishing fees, and the assignment of territorial rights to fishermen. Fishing fees could be used to offset the effect of rising real prices and would discourage fishing at low levels of stock abundance. The extraction of some rent from the fishery would incidentally provide the necessary budgetary framework for financing fishery conservation, research and management measures that are essential if rates of use are to be limited to sustainable levels. The other alternative mentioned is that of specific geographical rights to areas within the EEZ, referred to as TURFs (Territorial User Rights of Fishermen) (Christy, 1982; Smith and Panayotou, 1984).

Developing coastal States have perceived the benefits from the exploitation of their marine resources quickly for food or foreign currency by acquiring foreign fishing technology and the skills to use it through a variety of indirect mechanisms, each with its advantages and risks. Among these mechanisms is the licensing of foreign vessels for specified resources, areas, and levels of removal and, if the establishment of a national fishery is the final objective, through joint ventures, with full participation of nationals at all levels in the fishery. These mechanisms, while not excluding the possibility of developing a national fishery at a later date, allow some resources and resource rent to be extracted nationally, at the same time that data on the resource are being collected. All developmental strategies have major risks in the absence of adequate data; priority should be given to analysis of population dynamics, and should assist in avoiding ill-advised foreign over-investment in fleet and facilities, as well as providing the possibility of revenue through the use of shore facilities.

It is essential to ensure that exploitation levels in shelf fisheries do not exceed those that would result in radical changes to marine ecosystems and hence lead to a reduction of the possible options available to future generations of users of the marine resource (i.e. destroy intergenerational equity). Consequently, the control of overall fishing effort is emerging as a major priority for fisheries management (e.g. FAO, 1984b). The intensity of direct and incidental exploitation of resources and ecosystems, and the indirect effects of other human activities on the well-being of marine resources, should not exceed levels that compromise the attainment of a sustainable yield. Evaluation of the effect of exploitation requires continuous monitoring of the resource and its environment. Through an appropriate legislative framework, the level of exploitation should be responsive to changes in resource abundance and environmental change, and this is the context which has given rise to a Code of Conduct for Responsible Fisheries currently being developed by FAO (1994d, 1995a).

Developing appropriate models of the fishery and its ecosystem is an important step towards defining a desirable 'state' of the fishery, whether this is defined in terms of fishing mortality rate, biomass or allowable catch. The quality of the data needed for defining the appropriate state of the fishery and the long-term objectives for management is the first stage for management by a technical reference point based on a population model of the fish stock (FAO, 1993h, Caddy and Mahon, 1995) (Fig. 9). The second stage is determining the position of the fishery in relation to the reference point chosen. Experience shows that our accuracy of 'location' of the fishery in relation to a given management model is rarely better than plus or minus 20-30%, so that, to avoid overfishing, a precautionary approach is necessary (Garcia 1994a, b).

In most coastal and shelf seas, especially in the tropics and sub-tropics, the fishery resources are multi-specific and the fishery is multi-gear (e.g. FAO, 1978; Pauly and Murphy 1982; Smith *et al.*, 1983; Christen and Pauly, 1993). At the same time, the abundance of the few species of principal interest may vary considerably, seasonally and interannually, making fishing a risky business economically. This risk can be reduced, and fishing pressure eased on key species in the multi-species system, by first controlling the number of participants and their pressure on the stocks, but also by changing fishing gear according to season. Such a strategy, in a multi-species, multi-gear context, may be called "successional fishing" (Nagasaki and Chikuni, 1989). Multispecies gears such as trawls and some fish traps capture a range of species and pose a particular management problem, in that at high fishing pressure, the slow-growing, top predators can be reduced to a low abundance. It will be necessary to take trophic and other life history linkages into account in managing separate fisheries on trophically-linked species (see Brander and Bennett, 1989 for a simple example of this problem). One safeguard against over-exploitation and other adverse effects is the conduct of regular resource surveys.

Governments need to be fully aware of the economic and social penalties imposed by mismanagement, or lack of management, of fisheries. In the light of current Third World debt levels and economic restructuring, the governmental role in fishery management, especially in developing countries is still essential. Applying management measures successfully requires a degree of devolvement of responsibility to local or regional levels in order to be successful.

#### 2.2.4.1 Special problems of shared and straddling resources

Under the 1982 UN Convention on the Law of the Sea, jurisdiction over shelf resources lies with the coastal States, except for limited areas of shelf beyond 200 miles (see section 7.1). However, many resources, particularly for regions where many small EEZs have been delineated, as in the Caribbean Sea, are exploited by two or more States (so-called "shared stocks"). These lie across, or migrate across, boundaries between EEZs and the high seas (so-called "straddling stocks and highly migratory stocks"). Under the 1982 Convention, States are charged with co-operating to ensure sustainable management of shared marine resources, to use an existing fishery commission, or to set up such a body for this purpose. A significant number of such bodies now exist (see section 7.5). Such commissions should, *inter alia*, co-ordinate national management, set overall limits on removals, apply allocations decided by agreement between States, and co-ordinate surveillance to ensure that such regulations are respected. To date, there are a number of shared resources for which such a formal mechanism has not yet been applied. The resulting conflict of objectives, or lack of co-ordination between management authorities responsible for the exploitation of a shared fishery resource, has been one of the main reasons for declines in transboundary stocks in shelf areas (FAO, 1994c). The legal framework for managing transboundary resources under the 1982 Convention are discussed in Hayashi, 1993, and some of the practical problems of managing transboundary resources are discussed by Gulland (1980) and Caddy (1982).

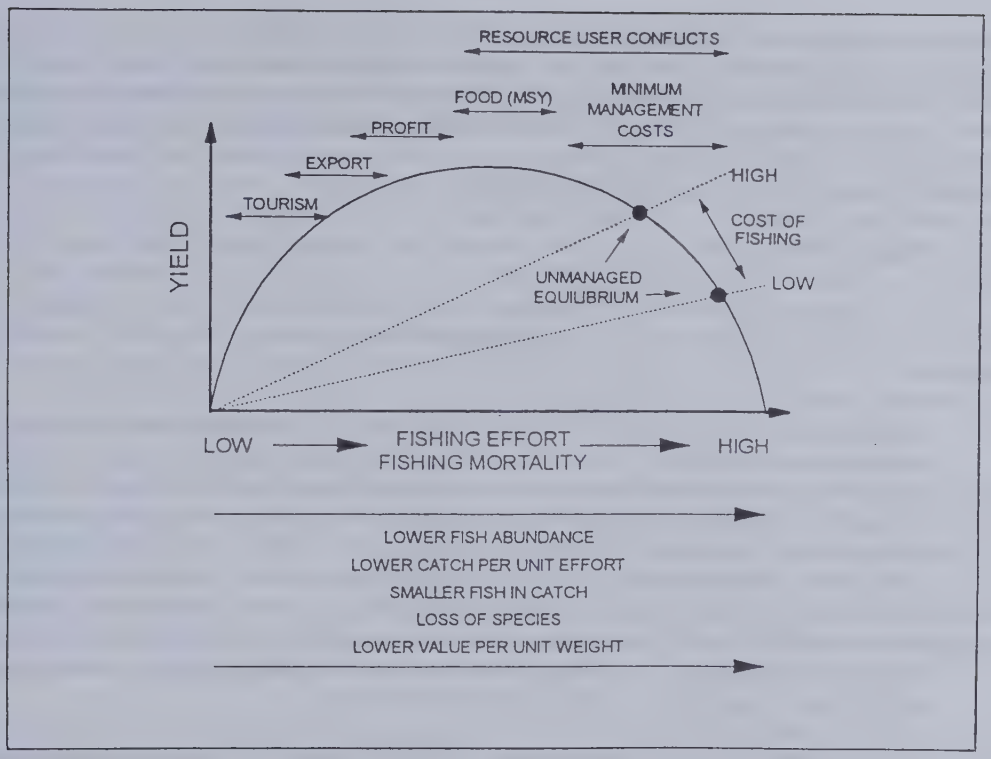



**Figure 9.** Some relative ranges for the fishing mortality rates corresponding to different objectives for marine resource use in the context of a surplus yield model (after Caddy and Mahon, 1995).

In the case of adjacent countries fishing a common stock, agreements on reciprocal access, as well as on surveillance, statistics, surveys and assessment, may reduce the costs of a managed fishery to both parties. States should co-operate to harmonize their management regimes and, as far as possible, their respective fishery research and national legislation in this field.

Serious problems are faced by fishery management authorities in managing the operations of modern fishing fleets, which can harvest a significant proportion of a stock in a short time and which are extremely mobile and independent in their operation. "Real-time" management, not only for a stock within a single EEZ but particularly for a shared stock (as defined above), requires integration of many diverse elements, such as inspection of catches and vessels in port and at sea, and the radio transmission of daily fishing data (e.g., catches, fishing effort, fishing area) by participating vessels. A computerized data system is needed so that the fishery can be closed when an agreed fishery management objective (e.g., the total allowable catch (TAC) or minimum catch rate) has been achieved.

Such a projected high-seas management system would be made up of a number of elements: a vessel licensing system and data base of vessel operations; realistic fishing fees by resource and category of vessel which reflect current market prices; regular updating of the results of regular research-vessel surveys to establish abundance of the resource; the existence of a team of resource experts to estimate and advise on allocating the resource of fishing opportunity; and mechanisms for consultation between all parties concerned. Aerial surveillance, involving standardized marking of vessels and fishing gear, and standard call

signs for vessels authorized to participate in the fishery, are modern options. A number of these aspects are touched upon in the FAO Compliance Agreement (FAO, 1994e) which encourages compliance of fishing vessels on the high seas with conservation measures in force, through a number of technical considerations. Vessel licence fees, penalties and other revenues should ideally be used to cover the cost of the above-mentioned operations before any surplus is returned to the national treasury.

### 2.2.5 Proposed Actions

The following actions (in **boldface**, with complementary text in italics) appear desireable options with respect to the **sustainable development** of coastal and shelf-sea resources:

(i) **Extraction of a realistic rent from users of the marine environment and resources, with appropriate penalties for misuse, and the elimination, where possible, of subsidies which encourage overcapitalization.** *(In practice, the only way that environments can be preserved and rent extracted is by reducing the access of users of the environment and resource to levels that can be supported without affecting the long-term productivity of the system, and can generate resource rent to pay for research and surveillance. Such measures include the issuing of limited licences to fish and the avoidance of financial incentives. Exclusive user rights to areas of shelf and the institution of closed fishery zones and/or seasons, (including marine parks or reserves) may be other applicable management mechanisms.*

(ii) **The collection of licence fees for use of the resources, and realistic penalties for infringements, such as illegal fishing or pollution, that affect the sustainability of the resource.** *Such fees should be commensurate with the value of the resource and collected by a designated resource management authority with powers of enforcement. Ideally, a proportion of the rent should be used for sustainable management of the resource before the surplus reverts to the national treasuries concerned. The use of some of the national income from the fisheries to pay for monitoring and control measures and, if possible, to support regional fishery management bodies and relevant research and conservation measures, should also be considered.*

(iii) **The establishment of a code of conduct for responsible fishing to guide the formulation of a management plan, with regular consultation between the industry and government, is a precondition for a successfully managed fishery.** *Modification of harvesting practices (seasons, areas, methods, gears), so as to avoid wastage (discarded fish) and to reduce the capture of non-target, regulated, protected or endangered species, and generally to reduce the impact of fishing on particular species and on the environment,* inter alia *fall under the provisions of a code of responsible fishing.*

(iv) **The provision of realistic financial support to fishery commissions and other bodies concerned with management of transboundary and straddling and migratory stocks is necessary if management is to be accomplished .** *The success of management of high-seas and transboundary stocks will also require verification of the location of fishing activities by independent monitoring or telemetry.*

(v) **The setting of explicit targets for management in relation to agreed reference points derived from accepted population models, the location of the current state of the fishery in relation to them, while taking a precautionary approach, are essential bearing in mind our uncertain knowledge of the state of the fishery.**

(vi) **Promotion of studies aimed at improving fishing gear, gear selectivity, and understanding the reaction of fish, marine mammals and marine reptiles to fishing gear and other man-made obstacles, and prohibition of the discarding of entangling debris such as fish netting and plastics at sea are needed to reduce the incidence of "ghost" fishing.**

(vii) **Development of contingency plans to deal with potential natural and man-made environmental disasters, and elaboration of mechanisms to resolve conflicts of interest among users of the marine resources and environment, are essential.**

(viii) **The promotion of investment in infrastructure to improve environmentally sustainable food-production capacity, such as zoned aquaculture facilities at appropriate levels of density, and artificial reefs is recommended.** *This promotion will require specific recognition of user rights over shelf resources, and the integration of coastal tourism and recreation. These actions can bring financially important inputs to coastal communities and the fishery sector, since successful sports fishing and underwater tourism enterprises require a higher abundance of fish and large specimens.*

(ix) **Measures should be instituted to protect biodiversity, in addition to specific measures to control fisheries.** *For example, the uncontrolled collection of shells and curios, and indiscriminate spearfishing will also have to be effectively discouraged to maintain biological diversity and ecosystem integrity of ecologically susceptible areas. Consideration should be given to incorporation into marine parks of significant proportions of critical habitats important to fisheries, such as inshore nursery areas, critical habitats or otherwise especially sensitive areas.*

(x) **Strict monitoring and control of the disposal of organic waste and nutrients into the shallow shelf-sea environment, should take into account the zonation of areas under ICZM or other such schemes, and not exceed the assimilative capacity of the receiving environment.**

## 2.3 RESOURCES AND ENVIRONMENTS OF ENCLOSED AND SEMI-ENCLOSED SEAS

### 2.3.1 Categorization of Semi-Enclosed Seas

Enclosed and semi-enclosed seas and, in some circumstances, archipelagic seas, are recognized as areas of particular value to mankind, because of the favourable environments they provide for human life along their littoral zones, and for the renewable resources and unique fauna and habitats they contain. They are also, actually and potentially, the most susceptible of marine water bodies to human influences, and have some of the features of large estuaries, with limited flushing characteristics and enhanced susceptibility to the effects of terrestrial activities.

Various criteria have been suggested for deciding whether a geographically distinct body of marine water constitutes a semi-enclosed sea; Alexander (1973) suggests an area of at least 50,000 $km^2$ with at least 50% of the circumference consisting of coastline and the connection to the outside sea consisting of no more than 20% thereof. The definition under

Article 122 of the UN Convention on the Law of the Sea is less specific geographically: "a gulf, basin or sea surrounded by two or more States and connected to another sea or the ocean by a narrow outlet or consisting entirely or primarily of the territorial seas and Exclusive Economic Zones of two or more coastal States".

This definition incorporates several key ideas:

(1) the potential effect of land on the marine system;

(2) the direct involvement of two or more States;

(3) a connection with another sea or ocean through a strait;

(4) the division of the sea area into territorial seas and/or Exclusive Economic Zones, in theory at least.

There are at least two other categories of semi-enclosed sea: those comprising areas beyond territorial seas where either EEZ claims have not been made (e.g., the Mediterranean) or where they conflict and the conflict has not been resolved (e.g., the Yellow Sea, the South China Sea).

The Convention definition excludes seas that are wholly national, such as the Beaufort Sea, the Sea of Marmara, or the Seto Inland Sea, even though, as for archipelagic seas and straits in general, the unhindered passage of marine resources from one jurisdiction to another through such wholly national waters is internationally recognized and accepted. This imposes a special obligation on the concerned States for conservation of international migratory resources while they are traversing straits and national seas.

Other climatic and social factors may be useful in the consideration of the categorization of semi-enclosed seas. Thus, Smith and Vallega (1990) refer to "core" seas, such as the North Sea, the Mediterranean, the Yellow Sea etc., mostly in temperate areas, along whose littorals large human populations enhance the risk of environmental and resource impacts, but where, until recently, a degree of resilience to the impacts of human activities has been evident.

Another category of semi-enclosed seas exists, comprising frigid seas (e.g., Hudson Bay, the Sea of Okhotsk, and the entire Arctic Ocean) and tropical seas (e.g., the Great Barrier Reef lagoon), in which the biological systems are intrinsically less robust to the influence of human activities, the effects of which are now beginning to be felt.

### 2.3.2 Impact of Human Activities

Fisheries of enclosed and semi-enclosed seas provide the first basis for evaluating human impacts on marine ecosystems as a whole. Some of the key features of semi-enclosed seas have been described by Ketchum (1983). The susceptibility of such seas to human activities can be summarized under four headings (adapted from Caddy, 1993a):

(1) the scale of riverine, atmospheric and coastal (direct terrestrial run-off) inputs relative to the rate of flushing to the ocean, and the catchment area and its rainfall relative to the extent of the semi-enclosed sea;

(2) the extent to which sills or basins modify the exchange of water with the ocean and within the semi-enclosed sea itself;

(3) the latitude, depth and, consequently to a significant extent, the temperature and stratification of the water mass;

(4) the size of the human populations residing along the littoral and within the catchment basin, the level of human activities and the land-use practices.

Hydrological complications may arise, depending on whether flushing is irregular, as in the Baltic (Rosemarin, 1990; Anon, 1990), or periodic, as may be suggested by long-term cycles in productivity, e.g. in the Adriatic Sea (Regner and Gacic, 1974) and the Bay of Fundy (Caddy, 1979).

Semi-enclosed seas with narrow connecting straits may show a gradient of features: in tropical and sub-tropical seas, the transition may be gradual, from fully marine, close to the entrance, to more saline water within the semi-enclosed sea which acts as an evaporation basin (e.g., Mediterranean Sea, Persian Gulf); in cold-temperate seas, the transition may be from fully marine characteristics, at the entrance, to near-fresh water within (e.g., the Sea of Marmara - Black Sea - Sea of Azov system and the Kattegat - Baltic Sea - Gulf of Bothnia system). Even largely open coastal seas such as the North Sea may show evidence of similar ecological transitions (e.g. Daan, 1989; DANA, 1989).

In the case of fully enclosed systems, such as the Caspian Sea and Aral Sea (Williams and Aladin, 1991) changes in water level have resulted from diversion or excessive use of inflowing rivers. This is a growing problem globally, with increased water withdrawals for human activities on land often being accompanied by increased loadings of nutrients and other materials in the remaining discharge. This has changed the nature of marine aquatic systems in general and estuarine systems in particular. The effects of runoff of domestic wastes on species diversity may be positive or negative depending on the amount of effluent discharged per day (Reish, 1980) and the assimilative capacity of the receiving basin, but is rarely positive on anadromous species.

The exchange rate with the ocean is very low in the Black Sea, the Baltic, the Mediterranean, the Red Sea, and the Persian Gulf. It is much higher in the Gulf of Thailand, the Yellow Sea, the North Sea, the Caribbean, the Sea of Japan and the South China Sea, but evidence is now accumulating that retention of polluted water masses close to the coast may lead to significant impacts of uncontrolled development even in more "open" systems such as the North Sea, (Boddeke and Hagel, 1991); the Adriatic (Degobbis, 1989), and the Mediterranean as a whole (UNEP/Unesco/FAO, 1988).

A significant proportion of the loadings of "core" seas, such as the Baltic and Black Seas comes from agriculture, especially excessive application of fertilizers, and intensive livestock rearing (Barg and Wijkstrom, 1994; Fan Zhijie and Cote, 1991). Phosphorus in runoff water is in part, eventually stored in sediments, but may be released into the water column especially under anoxic conditions (e.g. Abe and Pekpiroon, 1991). The discharge of nutrient-rich wastes is affected by human impacts, and in turn, affects riverine fish production (Ward and Stanford, 1989; Welcomme, in press). River runoff may boost primary production in otherwise nutrient-poor waters (e.g. Edwards and Pullin, 1990; Caddy, 1990). Such

nutrient discharges, if in moderation and if contamination by toxic wastes could be excluded, may enhance biological production in some fishery resources (Boddeke and Hagel, 1991; Caddy, 1993a). However, nutrient enrichment inshore and imbalance of nutritive elements also lead to unusual and dense phytoplanktonic blooms which, on decomposition affect benthis and demersal species and produce unaesthetic conditions close to the points of discharge, thus adversely affecting coastal activities such as tourism; the Adriatic Sea (a semi-enclosed "sub-system" of the Mediterranean) is a good example (see Vollenweider *et al.*, 1992).

The concentration of phytoplankton production in some marine areas is readily detectable from space, through the chlorophyll pigments involved (e.g. NSF/NASA, 1989) and has been used to build a global atlas, which illustrates the overriding importance of inshore areas for marine food production.

High production of microscopic algae in coastal waters of the North Sea has even been implicated in the generation of acid rain, through oxidation of dimethylsulphide (DMS) to sulphur oxides; DMS is a gas given off by marine plants under nutrified conditions (Holligan and Kirst, 1989).

Nutrient enrichment has long been recognized as important in freshwater ecosystems. Its role in marine environment is more recently becoming recognized (e.g. Brockmann *et al.*, 1988); and the need for environmental management of enclosed coastal seas is becoming more evident and urgent (see Goda *et al.*, 1991). Several levels of eutrophication may be distinguished, to which the following descriptors may be applied (adapted from Caddy, 1993a):

(1) **Oligotrophic** - characterized by low biomass, low availability of nutrients, trace metals and/or growth factors. The south and eastern Mediterranean, as well as many semi-enclosed seas in their pristine state, and the Sargasso Sea, are (or were) examples of oligotrophic water bodies.

(2) **Mesotrophic** - moderately-enriched systems with a well developed pelagic ecosystem dominated by a resident biomass of small pelagic fishes and an oxygenated benthic ecosystem contributing significantly to fishery production. River-driven marine catchment basins, such as the North and Yellow Seas, are typical examples.

(3) **Eutrophic** - very high primary production as a result of high nutrient levels, with substantial detrital "rain" promoting heterotrophic bacteria and flagellates leading to seasonal or permanent anoxic zones in bottom water and sediments, with corresponding adverse impact on the benthos and on demersal food webs and high standing crop of small pelagic fishes and zooplanktivores supported by high densities of planktonic herbivores. Certain coastal zones become eutrophic due to high levels of nutrient discharge arising from human activities, and, to a lesser degree, this occurs naturally in upwelling areas. Examples here are the Black and Azov Seas in the 1940s to 60s, and the upper Adriatic.

(4) **Dystrophic** - important chemical changes due to excessive input of nutrients, with close to permanently low oxygen levels or anoxia leading to the elimination of most benthic and exploitable demersal fish stocks. The northwestern Black Sea is currently the best example.

Experience in the Mediterranean, the Seto Inland Sea and the Black Sea suggests that, although moderate levels of enrichment of originally nutrient-limited marine systems may favour production and even suspension culture of some bivalve species and higher production of small pelagic fish of low economic value, they do so at the expense of often more valuable bottom-dwelling fish and crustacea. Increased nutrients in fresh-water run-off to semi-enclosed seas may also accelerate phytoplankton growth to the point that it adversely affects aquatic vegetation by reducing light penetration, especially if accompanied by a high load of suspended sediments. Contrarywise, the reduction of nutrient runoff (as in the case of the River Nile following construction of the Aswan Dam) can lead to a decline in marine fish catches (Wahby and Bishara, 1981)

As noted, waste discharges, if uncontrolled, lead to eutrophication, subsequent oxygen depletion and seasonal (as for the upper Adriatic) or semi-permanent anoxic conditions in deeper water (e.g., in the Baltic Sea (Hannson, 1985; Hannson and Rudstam, 1990; Wulff *et al.*, 1990). Anoxic conditions have also moved upwards onto shelf areas in the Black Sea (Mee, 1992; Sorokin, 1983, 1993; Zaitser, 1993), thus extending the naturally anoxic conditions that prevail in the bottom waters of this water body, with disastrous effects on the benthos and demersal fish. Long-lived reptant and burrowing macro-invertebrates may disappear, and short-lived species adapted to very low environmental oxygen levels may become abundant. There is an ecosystem adaptation up to the biological limits posed by the environment, but the new components of this ecosystem added by accidental introduction or immigration of exotic species, (now better adapted than the native species to the changed environment) are rarely those of interest for human exploitation.

Blooms of toxic phytoplankton species arising from the disposal of nutrients and other compounds into the sea can lead to impacts on mariculture and fisheries (ICES, 1992b; Richardson, 1989), necessitating the temporary prohibition of the sale of affected fish products. Untreated sewage can lead to the risk of viral contamination of shellfish and consequent human illness. Environmental degradation can promote the outbreak of infectious diseases (Snieszko, 1974), and can also affect the health of fish in contaminated areas (e.g. Dethlefsen, 1980, 1989; Mellergaard and Nielsen, 1990) and cause fish disease. Note that, even with primary treatment, the nutrient impact of sewage outflows remains largely unchanged; consequent over-fertilization can cause fouling and clogging of nets and cages used in aquaculture (Barg, 1992).

Intensive aquaculture is itself a source of over-fertilization of those semi-enclosed seas that have a limited exchange of water with the ocean, even though their sheltered conditions and ease of access make them initially attractive for aquaculture. Setting criteria for biological loadings of fjords, bays and lagoons as a result of cage culture of fish is already feasible, but defining a "favourable" level of aquatic enrichment, from the standpoint of the wild fishery resource, is still very difficult.

A comparative approach to describing the changes in these ecosystems is needed. The main features of semi-enclosed seas (and even more so, enclosed seas such as the Caspian and Aral Seas) show close parallels with stressed freshwater systems, notably such well studied systems as the North American Great Lakes (Regier, 1973; Regier and Henderson, 1973; Regier, 1979; Rapport *et al.*, 1985). Flushing times may be long: for example, a time of some 80 years has been estimated for the Mediterranean as a whole. In such environments, nutrients and toxic materials can accumulate rapidly. The effects of nutrient enrichment and overfishing in the North American Great Lakes as well as being synergistic are, in many ways, similar to those in semi-enclosed seas; (Regier *et al*, 1988). There is a decline in ecosystem diversity, progressive dominance of the production system by short-lived, especially pelagic, species, and by exotic or introduced species (Regier, 1973, 1979).

The separation of these two types of human impacts on inland and semi-enclosed seas has been rendered especially difficult by the concurrent growth of industrial fishing and of impacts of population growth, industrialization and agro-industry, especially since the Second World War.

Recruitment, mortality and growth of a fish stock are affected by the impacts of other users of the aquatic habitat and its catchment area; such impacts arise potentially from all up-stream economic activities, such as industry and agriculture, as well as from fishing. One of the major constraints to effective action relates to the dispersion of responsibility among many national and international institutions having competence in various aspects of resource and environment use.

### 2.3.3 Potentials and Constraints for Sustainable Development

Intergovernmental bodies have already been set up for several semi-enclosed seas. The Helsinki Commission and Baltic Sea Fishery Commission are concerned, respectively, with the environment and fisheries of the Baltic; likewise, the UN Environment Programme's Mediterranean Action Plan and FAO's General Fisheries Council for the Mediterranean, for this semi-enclosed sea. Improved collaboration between these bodies is essential.

The development of the fisheries of semi-enclosed seas has witnessed a number of dramatic changes in the ecology of these water bodies that are attributable not only to the effects of fishing, but also, and perhaps independently, to the effects of the discharge of wastes from human activities, toxic or nutrifying or otherwise into the marine environment.

Two largely simultaneous and synergistic processes may be noted:

(1) The reduction in the numbers of apical predators (notably seals and small cetaceans, as in the Baltic, Mediterranean and Black Seas), and in the numbers of large predatory fish (such as bluefin tuna in the Mediterranean, and turbot, bonito and bluefish, in the Black Sea: Ivanov and Beverton, 1985; Caddy and Griffiths, 1990). Some, but not all of these effects can be attributed to overfishing. Reductions in predator-population size may, in some cases, have contributed to increases in prey species. In some heavily fished areas, such as the North Sea, fishing has been progressively aimed at species lower in the marine food chain, with larger catches of less valuable small, short-lived species (e.g. Pope and Knights 1982; Daan 1989).

(2) Increased discharges of organic materials and nutrients have had impacts on the biological systems supporting fisheries, and in particular have also led to increases in planktonic production, thus increasing food available to larger components of the food web.

Two types of effect corresponding to these processes may be distinguished:

(1) **"Top-down" effects**: The removal of predator control can lead to increases in abundance of prey species of fish and other organisms. This is rarely of significant advantage to fisheries, since other predators may emerge and the larger predatory species lost generally have a higher value. As in large lakes (e.g. Northcote, 1980), a high abundance of plankton-feeding fish may lead to reductions in the zooplankton and to increases in phytoplankton, with loss of water clarity and adverse impacts on the bottom vegetation which is essential to many demersal species.

(2) **"Bottom-up" effects:** These lead to increased phytoplankton blooms as a result of enrichment; these phytoplankton blooms are often of species different from those found in unenriched waters. These blooms can affect marine vegetation by reducing light penetration, and in decomposition, lead to seasonal and eventually permanent anoxia of bottom and shelf waters. After an initial increase in production at low levels of impact, this can cause a decline in the benthos, the crustacean and molluscan shellfish, and in the demersal fish. In the pelagic food web, zooplankton species, often atypical of the unenriched environment, increase in abundance. Initially, they support growth of populations of small pelagic fish, but also of other pelagic predators of no commercial value, such as medusae (jellyfish) and ctenophores (Black Sea). Conditions for the production of jellyfish may be related to intrusions of salt water into shallow fertile estuaries, such as those leading into the Sea of Azov (Volovik *et al.*, 1993): these intrusions, in turn, are related to excessive withdrawals of fresh water for agriculture and industry. Invertebrate predators, such as jellyfish and, more recently, ctenophores, feed on fish larvae and, in combination with intensive industrial fishing on fish populations, may have been responsible for collapses in anchovy stocks in the Sea of Azov (Avedikova *et al.*, 1982; Zaitsev, 1993) and in the Black Sea (Caddy and Griffiths, 1990), and more recently, also in the Sea of Marmara (GFCM, 1993; Shiganova *et al.*, 1993).

We may note incidentally that a 'mixed mode' mechanism has been described, namely, 'wasp-waisted' food webs (Rice, in press). These appear typical of some low diversity, high productivity, food webs in upwelling areas, where fluctuations in the large biomass of small pelagic fish such as anchovy or sardinella plays a key role in impacting both their predators (bottom up) and their prey (top down). Such fluctuations involving changes in species dominance, occurred in these systems even prior to human exploitation (Holmgren-Urba and Baumgartner, 1993).

The introduction of exotic species into a particular marine environment by man, intentionally or by accident, has increased considerably, and changes in the environment have both facilitated this process and resulted from it (Carlton, 1989; Carlton and Yeller, 1993). The establishment of exotic species introduced as pests or parasites through careless aquaculture, through pumping of ballast tanks of shipping, or through man-made canals, has changed the fauna of many enclosed and semi-enclosed seas. The introduction of pathogenic organisms has often adversely affected native and introduced species alike, particularly cultured shellfish. The context for such issues is addressed in Article 196 of the 1982 UN Convention on the Law of the Sea.

In relation to the introduction of foreign organisms, FAO has collaborated with ICES in the preparation of a "Code of Practice for Consideration of Transfers and Introductions of Marine and Freshwater Organisms" (ICES, 1995). The International Maritime Organization (IMO), in cooperation with ICES is also preparing guidelines for minimizing the possibility of transmission of harmful organisms in ship ballast water.

### 2.3.4 Proposed Actions

Smith and Vallega (1990), suggest a sequence of actions for assessing the use of semi-enclosed seas. Their ideas provide some inputs to the following proposals for **sustainable development** of these marine areas:

(i) **Coastal States should cooperate through meetings of a regional management body attended by involving decision-makers representing those States, charged with developing, co-ordinating and implementing national actions, and with maintaining the resources and the marine environment in a condition such that living marine resource management is a feasible option for the indefinite future.** (Ideally, the same body should concern itself with management of both the environment and living marine resources; otherwise, the bodies having such separate competencies should coordinate their work. The membership of such bodies should ideally include all entities lying within the corresponding Marine Catchment Basin (MCB), whose inland and offshore boundaries for action should be defined).

(ii) **Marine Catchment Basin (MCB) principles should be introduced into the management of the enclosed or semi-enclosed sea and its watershed, with target levels set for discharge of toxic wastes, nutrients, silt and soil run-offs and airborne pollution entering the sea, and strict control of such discharges.** (Development planning for the sea should be based on integrated environmental management of the entire catchment basin, including the inflowing rivers, their effluent discharges, as well as the marine environment they affect).

(iii) **Alternative regional scenarios should be developed for the use of the living resources and the environment, taking into account the interest and interactions between concerned parties.**

(iv) **Common data bases on the environment, resources and socio-economic activities within and around the sea of concern, are needed as a basis for action.**

(v) **Solutions to the problems of transit through straits and estuaries of migratory fish species should be sought, especially where such transit affects traditional access to a resource within other jurisdictions.**

(vi) **A co-ordinated programme of research with free exchange of information between the countries concerned should be pursued, having as priorities: resource management and ecosystem studies, the monitoring and estimation of discharges of water-borne pollutants and suspended solids, as well as their transmission via the atmosphere from land to the sea; and the economic consequences of consequent ecosystem changes.**

(vii) **Measures to avoid activities harmful to enclosed and semi-enclosed seas need reinforcing, notably the discharge of industrial and domestic wastes and oil, and of practices that encourage the introduction of exotic species into these ecologically unique environments.**

(viii) **Local initiatives should be subordinated to regional agreements, since actions within each sub-zone of an enclosed or semi-enclosed sea are ineffective without proper reference to human interactions in the whole marine ecosystem and its surrounding catchment basins.**

## 2.4 RESOURCES AND ENVIRONMENT OF THE HIGH SEAS AND THE OPEN OCEAN

### 2.4.1 Oceanic Resources and High-Seas Fisheries

The state of high-seas resources has been conveniently summarized by Garcia and Majkowski (1990) and FAO (1993c, k). The main high-seas resources are: whales; tunas and related species; salmon; oceanic squids; sharks; oceanic horse mackerel; mesopelagic fishes; marine turtles; Alaska pollack; pomfrets; Pacific saury; and a few other potentially important species.

Of the 400 or so commercial or potentially commercial species considered to be oceanic, few are subject to directed fishing. The biological information available on most oceanic resource species is usually poor, and is only relatively good for large tunas and some whales. Tunas, salmon, sharks, billfish and squid are now the main resources being exploited on the high seas, except for the demersal and small pelagic resources of continental shelves lying outside 200-mile limits, which form a special case. Tunas, being apical predators in oceanic systems, feed on a number of smaller species such as frigate mackerel, squid etc., which, at least in theory, could yield perhaps ten times the landings from tuna stocks. However, tunas effectively integrate the whole oceanic food chain and, as apical predators, make it available to man in high-value, accessible schools. With the exception of some squid stocks, tuna prey species lower in the trophic chain are not often exploited, partly because of the costs of fishing far from port, of low market prices, or because densities of occurrence and availability to fishing are low.

Some tuna stocks are heavily exploited, most marine turtle and some seabird populations populations are under direct or indirect pressure from human activities, and few shark resources have sustained prolonged local exploitation without collapse. Many of the large whale species have been overfished in the past, and may still be depleted or even on the verge of extinction, but whale population estimates are imprecise and now largely based on sightings. Concern has recently focussed on dolphin populations, and these may be endangered in some enclosed seas and coastal areas. There is some evidence, however, that populations offshore in areas such as the eastern Pacific, are being maintained, even though by-catches in some fishing gears need to be monitored, and population estimates improved.

New fisheries are now possible for relatively few important unexploited resources, but oceanic squid, mesopelagic fish, and krill in the Antarctic, could still have significant unused potential, although scientific opinion here is less optimistic than formerly. For mesopelagic fish, potential yields could be large, but, given low unit values, high cost of fuel and the high level of harvesting technology required, net economic yield may not be great. Such a development merits encouragement, since a proportion of these large resources, if used for producing fish meal, may substitute for small pelagic fish, and increase the availability of the latter for human food instead of for the production of meal, as is presently substantially the case (FAO,1993b).

### 2.4.2 The Open-Ocean Environment

The GESAMP report on the State of the Marine Environment (GESAMP, 1990) noted that, although the open ocean was still relatively clean, some contamination was occurring, with atmospheric routes for contaminant transmission being of primary importance. Also of considerable concern is the widespread occurrence throughout the world oceans of floating plastic debris which may impede (by entanglement etc.) movement, and interfere with the feeding of birds, mammals and fish species living in or off the surface layers of the oceans.

### 2.4.3 Management of High-Seas Fisheries

#### 2.4.3.1 The management units for ocean systems

We know that the exploitation of certain species affects the abundance of the others through predator/prey linkages or by inter-specific competition. Current perceptions of this linkage of individual species in an oceanic food web raise the problem, analogous to that of stock boundaries for single species, of deciding what are the practical geographical limits of oceanic systems within which an integrated approach to management should operate. This recognizes the Darwinian concept (e.g. Sinclair, 1988), that self-reproducing populations should be managed throughout their range, irrespective of jurisdictional boundaries that lie across the range of the unit stock in question (FAO, 1993b, k, 1995e).

One currently popular paradigm is the Large-Scale Marine Ecosystem (LME) concept which would see certain large areas of ocean, such as the Benguela Current system or the Bering Sea, under co-ordinated management by concerned States having a legitimate interest in the marine resources of the area. LMEs would necessarily cut across maritime boundaries, would require an intensification of research by all parties to understand functional linkages, and would need to be integrated with existing management structures, or require new ones. Decisions would have to be made as to the priorities to be given to different exploitation scenarios. It seems certain, however, that management on a species-by-species basis, the approach that has most commonly been used to date, is less than satisfactory. Interrelationships between species (competitors, prey and predators) and environment and fishery need to be well understood for LME management to be applied, which is not currently the case.

With respect to high-seas fisheries management, the principal conclusions of the FAO Technical Consultation on High-Seas Fishing (Rome, 7-15 September 1992; FAO, 1992a) provide the basis for the following commentary:

(i) **high-seas fishing will continue to increase, as will the need for management; problems of shortage of data are unlikely to be resolved; hence, the "precautionary approach" (see section 4.4.2) should be applied to development in this field;**

(ii) **the UN Convention on the Law of the Sea (Annex IV), supplemented by the relevant decisions of the UN Conference on Environment and Development (see sections 7.1 and 7.3) and the Declaration of Cancùn (see Annex V), provide the principal legal framework for the sustainable development of high-seas resources;**

(iii) **there is a need for a code of conduct for responsible fishing of high-seas and other marine resources; see also section 4.4);**

(iv) **the reflagging of fishing vessels to flags of convenience, so as to avoid conservation and management measures and fair-trade practices, should be strongly discouraged;**

(v) **flag States should maintain a national register of fishing vessels capable of operating on the high seas and so authorized;**

(vi) **high-seas fishery management should be, wherever possible, undertaken by regional or sub-regional organizations, which will require the strengthening of regional fishery bodies, and should also, cover whole stocks and take into account all removals therefrom;**

**(vii) high-seas fishery management should take environmental considerations fully into account and be based on the best possible scientific data and information, including accurate and complete fishery statistics, with due consideration being given to legitimate confidentiality of such data, information and statistics;**

**(viii) effective monitoring, control and surveillance (MCS) is essential for high-seas fishery management, and requires application of new technology;**

**(ix) there is a need for more research on high-seas resources and environment and for its application to fishery management;**

**(x) Maximum Sustainable Yield is no longer a valid target reference point for high-seas fishery management, and other reference points should be examined;**

**(xi) developing countries must be assisted to obtain the necessary capacity to participate in and manage high-seas fisheries;**

**(xii) greater public awareness of high-seas fisheries should be pursued.**

The FAO Council, at its 102nd session (November 1992), endorsed the conclusions of the Technical Consultation as well as accepting the Declaration of Cancùn on responsible fishing as a basis for future action in developing a code of practice for responsible fishing.

2.4.3.2 The problems of stocks straddling EEZs and the high seas

The UN Convention on the Law of the Sea extended the provisions for conservation of highly migratory species to areas and resources beyond national EEZs by asserting that "coastal States and other States" should "co-operate directly or through appropriate international organizations with a view to ensuring conservation and promoting the objective of optimal utilization of such species throughout the region". However, the need for more explicit conservation mechanisms, and a code of practice governing fishing operations on the high seas, has become progressively more evident in recent years.

Although the Convention's term "High Seas Resources" refers to oceanic resources lying beyond 200-mile limits, there are, in practice, few living marine resources whose ranges do not overlap to some extent one or more coastal State jurisdictions. This has profound implications for resource exploitation and management, since many nominally "High Seas Resources" should more properly be regarded as straddling stocks with adjacent EEZs.

Distant-water fishing vessels operate outside the jurisdiction of their countries and although reporting by their own fleets is often required by distant-water fishing nations as a condition of fishing, it is very difficult for the flag State to enforce, given the prohibitive cost of at-sea surveillance. This problem includes the difficulty of obtaining unbiased fishery data, especially on by-catch (Alverson *et al.*, 1994). The incentive for falsification of declarations is a real one, with several real sources of bias being possible; for example:

(1) a proportion of catches of a species taken under licence in one EEZ may be declared as coming from an unregulated (high seas) area or from the EEZ of the flag State;

(2) given the mobility of distant-water fleets and the significant time spent at sea in one trip, catches may be taken from sea areas under different jurisdictions, possibly including more than one ocean;

(3) illegal catches of a regulated species may be declared as coming from an unregulated area, or, after transformation at sea, as consisting of an unregulated species;

(4) illegal catches may be sold or trans-shipped at sea or in an unregulated port to another vessel.

Any management scheme that is intended to control fishing in high-seas areas must find a solution to these potential loopholes and, to the problem of at-sea surveillance.

The above-mentioned unresolved issues, and the need for a common data base for high-seas fisheries, have become progressively more evident in recent years, but the poor state of our knowledge of high seas resources, and the lack of an established framework for limiting the impact of human activities on these resources, were highlighted most recently by Resolution 44/225 adopted on 22 December 1989 by the United Nations General Assembly on the issue of large-scale pelagic driftnet fishing.

Following the principle that "evaluation and management of a stock must take account of removals throughout its range of distribution", an exchange of information and co-ordination of harvesting are prescribed under the UN Convention on the Law of the Sea for marine resources, including those taken outside EEZs.

Several major problems are evident in practice:

(1) Few individual nations whose EEZs overlap the distribution of a high-seas resource are likely to reduce their exploitation rate to accommodate catches taken by the fleets of other nations in adjacent EEZs, and even fewer are likely to accommodate, within an overall total allowable catch, the needs of distant-water fleets fishing the same stocks in international waters, unless they are signatories to an international agreement or are members of a fishery commission to which they have delegated powers to manage catches of the species in question throughout its range. They are more likely to complain, justifiably, that catch rates within their EEZ could be affected by uncontrolled fishing on the same stock in areas outside their jurisdiction. In these circumstances of a lack of reciprocal recognition of a right by others to use the same resource, over-exploitation inevitably reduces the value of the resource to all parties (Caddy, 1982).

(2) Vessels from flag States that are not signatories to a fishery commission or to a joint fishing agreement at present, have no legal obligation under international law to control their catches on the high seas; nor is there currently any international control and surveillance capability for areas outside EEZs.

(3) Catches taken on the high seas by individual vessels of a distant-water fishing nation or an adjacent coastal State (whether or not the flag State is signatory to an accord), are not always recorded accurately as to place of origin. As a result, the data on catch, effort and by-catch needed to carry out a stock assessment are usually incomplete or biased, making evaluation of the impact of fishing imprecise.

(4) Distant-water fleets are at sea for long periods, making the presence of an official observer on board difficult. These fleets may move rapidly from one jurisdiction to another in the course of a fishing trip, may process the catches at sea into a less easily recognizable form, and may trans-ship them to another vessel in port or at sea, thus making it difficult, on landing, to establish the place and date of origin and the quantities caught.

These kinds of problems require radical new solutions in which the uncertainty of current information as resources will require a precautionary approach (e.g. Garcia, 1994a, b) but also where the application of high technology will certainly play an important part, and in which a new legal and management framework will be needed to oversee exploitation of high-seas resources. These issues and others are currently being addressed at the United Nations Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks underway in New York, and will hopefully lead to a more controlled exploitation regime.

2.4.3.3 Oceanic data bases for decision-making, and potential control measures

International fishery management evidently depends on the exploitation of a wide variety of types of information, and there is a growing realization that it would greatly benefit from the development of Geographical Information Systems (GIS) (e.g. Maguire *et al.*, 1991). This tool, first developed for rationalizing multiple land use, has been extended to coastal zones and should be further developed for oceanic resources. However, information on the ocean environment is not easily accessible to fishery decision-makers, and this applies in reverse to other users of the marine environment who have not always taken the needs of marine resource management into account.

All of the foregoing considerations suggest the need for some coordinating mechanism to monitor and regulate high-seas fisheries. Such a body or bodies should maintain close contacts with all States having a legitimate interest in high-seas fisheries, and should receive guidance from existing regional fishery commissions nominally responsible for such resources but which, in practice, lack the mandate to control resource harvests that fall under more than one jurisdiction. A global mandate would be required to maintain a common data base of high-seas catches by statistical areas, or lists of vessels fishing high-seas resources, with standard international marking of vessels and gear. Mandatory reporting procedures for registered vessels would need to be set up and controlled. Progress towards such a goal has been notable in recent years but such a uniform global system does not yet exist.

Major problems remain with such a hypothetical global scheme, mainly of a legal, organizational and financial nature, but also of a technical nature, particularly with respect to verification. Technological solutions are feasible in theory: a "black box" could be installed on registered fishing vessels which would continuously monitor, via satellite, vessel position and various telemetric devices, engine and winch operation etc., which would indicate that fishing operations are underway. Such systems will not, however, assist in documenting illegal fishing practices, and the simplest but not infallible solution has been the recourse to prohibition of fishing by certain gears within specified areas.

A particular problem of high international profile in recent years arises from the poor species selectivity of the monofilament nets used in the so-called large-scale pelagic drift-net fishery; these nets differ considerably from inshore gill-nets in their size (up to 100 km) and in their fishing action, which tangles all species coming into contact with the gear, including fish, squid, birds (e.g. ICES, 1994b) and mammals (Northridge, 1991) (FAO, 1990; Northridge, 1984, 1991). Discards of non-target species caught in these large-scale nets can be high, and may include not only marine mammals and birds but also small tunas and other fish not considered of commercial importance. Difficult, legal issues are raised here for high seas fisheries (Hey *et al.*, 1991), and the UN General Assembly resolution 44/225 of 22 December 1989 addressed this problem and recognized the need to ensure that fishing

gear is designed in such a way that the target species is caught preferentially, with only minor catches of other species. This poses a major challenge to fishery technologists. One other disincentive to irresponsible fishing practices discussed recently involves trade measures against products resulting from harmful fishing practices.

There are other difficulties with respect to illegal by-catch of non-target species: incidental catches of regulated species outside prescribed areas, seasons and catch limits. Prohibited salmon catches in squid gill-net fisheries can in theory be monitored in port, since these species are less likely to be discarded. Kills of species that are taken incidentally and discarded at sea, such as marine mammals, cannot be quantified using this approach which requires rigorous, but problematic, evaluation at sea of the impact of fishing gears according to season, area and mode of fishing, and the development of more selective gear and procedures that satisfy ecological criteria (ICES, 1994a). More imaginative solutions to monitoring high-seas fisheries may permit a more flexible response than wholesale banning of a whole category of fishing methods which are capable of being improved and, after modification, of contributing to the achievement of sustainable development.

### 2.4.4 Proposed Actions

The following actions (**boldface**, with complementary text in italics) seem appropriate with respect to the **sustainable development** of high-seas resources:

> **Mechanisms are required for managing the resources of high-seas areas.**
> *The results of the ongoing UN Conference on Straddling Fish Stocks and Highly Migratory Fish Stocks may provide a basis for this, which would depend on, inter alia: maintaining and exchanging up-to-date registries of licensed vessels; employing real-time fishery reporting procedures and a system of surveillance using the latest modern technology; developing and maintaining a data base on stock sizes and removals and on changes in the ocean environment relevant to living resources; providing to the regional fishery commissions timely national information on fishing activities and on the state of resources overlapping relevant jurisdictions; and co-ordinating resource evaluations with the countries and regional fishery commissions concerned. It would also provide, particularly for the major oceans, a mechanism for co-ordinating the various regional commissions, and could incorporate the requirement for preservation of the oceanic environment, as well as the resources, within their terms of reference.*

## 2.5 ANTARCTIC RESOURCES AND THEIR ENVIRONMENT

### 2.5.1 State of the Resources

The Antarctic Ocean is one of the few areas where an ecosystem modelling approach is specifically incorporated in the framework underlying resource management (CCAMLR, 1993a, b). If we examine the state of the resources that are currently exploitable in the Antarctic, (see Fischer and Hureau 1985), there is little reason for congratulation with respect to most whale stocks and finfish, even if for most non-exploitable Antarctic and sub-Antarctic living resources (with the exception of some species such as Albatrosses taken incidentally in some types of fishing operations further north), the situation is relatively good.

The very slow-growing and late-maturing demersal fish resources (e.g. Notothenia sp and Champsocephalus sp, and others in Fischer and Hureau (1985) and Gon and Heemstra (1990)), have been heavily affected by fishing. This was carried out from the 1970's, largely by former socialist countries operating under non-economic criteria (Koch, 1992). In some

cases, earlier quotas set by CCAMLR have not been filled, for reasons of current low population sizes. No catches of icefish were reported in 1992/3; in part due to continued declines in stock size. The problem of control of Antarctic fisheries seems not one of the adequacy of the underlying philosophy, but that monitoring of fishery regulations in such a large, inhospitable area (as well as obtaining the necessary data for stock assessment) is close to impossible.

The same comments on fish may also apply to the harvest of the krill, Euphausia superba; a species which underlies most food webs, (e.g. Miller and Hampton, n.d.), and is present at very large biomasses. Although previously the catch had been some 300,000 t, in the 1992/3 fishing season it fell to about 87,000 t, and the likelihood that a fishery operating under market conditions can make a profit with current technology on these resources remains uncertain. Some parties have expressed concerns however that even harvesting a small proportion of the standing stock locally to bird or seal colonies could lead to food depletion for less mobile breeding concentrations of land or ice-based resources.

The incidental capture of widely migrating albatross in tuna surface fisheries in the South Pacific has been considered one responsible factor why some bird populations, such as the Southern Albatross, are at low levels. The formerly heavy exploitation of baleen whales, which preferentially feed on krill in the Antarctic, may have allowed increases in other species dependent on the krill-based ecosystem, such as the crabeater, leopard, Weddell and fur seals (Institute of Biology (UK), 1985), although other authors have found relatively minor overlaps in the diets of these latter species (Siniff 1988). The recovery of the large whale populations is proving to be slow and they may need protection during their migrations outside the Antarctic Whale sanctuary recently declared by the Whaling Commission south of Latitude 40 degrees S.

Other resources of the Antarctic and sub-Antarctic have attracted attention, including some crustaceans, and the cephalopods (Rodhouse 1989), but commercial exploitation is yet to get underway for obvious reasons of high costs of operation. The risk remains, however, that in absence of the usual level of coastal State control that applies in other areas, it will be difficult to effect proper surveillance of responsible harvesting levels.

The natural environmental stresses in the Antarctic ecosystem make it particularly susceptible to changes due to external factors. Beside fishing, atmospheric contamination, albeit at low levels, due to human activities in the Northern Hemisphere, is growing, and has already affected the ozone layer which provides important protection against ultra-violet radiation (Bidigare, 1989; Karentz, 1991).

### 2.5.2 Protection Measures

The Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR) covers all marine resources, including mammals and birds, south of latitude 60°S, and provides a prototype for any management scheme of the LME type. The objective of the Convention (CCAMLR, 1993a) is "Conservation" which it equates with "Rational Use". It aims at preventing the reduction of any population, whether by direct exploitation, exploitation of its essential prey species, or deleterious transformation of the environment, to a level that may endanger its stable recruitment. Thus, despite the large biomass of, for example, krill and cephalopods in the Antarctic, their rate of replenishment, distribution pattern, and

importance as food for terrestrial and aquatic species is intended to determine the allowable extent, area and season of removals. Protection is particularly required near bird and mammal colonies, and for birds and mammals, close to expanding areas of human activity in the Antarctic. In this connection, the role of the Antarctic for monitoring global environmental changes is well recognized (SCAR 1993).

### 2.5.3 Proposed Actions

The following actions, *inter alia*, seem appropriate with respect to the **sustainable development** of Antarctic resources:

(i) **Increased research on Antarctic living marine resources, with the requirement that this research be co-ordinated so as to reduce unnecessary duplication of effort, and should take into account the growing impact that Antarctic scientific settlements themselves are having on an undeveloped area. Research in the Antarctic plays an essential role with respect to the monitoring of global climate variations and of global environmental conditions in general.**

(ii) **A careful approach to exploitation is needed that would not impede utilization of Antarctic resources but would ensure that access to these resources be subject to a harvesting regime limited in time ans space.**

## 2.6 APICAL PREDATORS, MARINE MAMMALS, REPTILES, BIRDS AND ENDANGERED SPECIES

The last two centuries have witnessed the depletion of a number of populations of marine birds, reptiles and mammals which interact directly, or indirectly, with man's harvest of marine products (see Northridge, 1984). In certain cases, e.g., the sea otter and several seal populations, (Ridgeway and Harrison 1985) such as the Pacific fur seal (Mitchell, 1973; FAO 1978b), recovery occurred once appropriate legislation was introduced, aided evidently by regeneration from small surviving fringe populations or unprofitable low-density populations. Several cases of extinction have occurred (e.g. the Steller sea cow; FAO, 1978b; Ridgeway and Harrison, *op. cit.*), and there are others where the species is currently considered to be threatened or endangered (Jefferson *et al.*, 1993). Fishing or hunting has been the cause of many of these near-extinctions. In other cases, such as those of the dugong and sea turtles (Ogden, 1989), human competition for suitable environment, often degraded by man, may have been the predominant cause. Natural fluctuations and sudden crashes and recoveries in the abundance of sea bird colonies close to exploited small pelagic stocks (Anon, 1995) may be rendered more extreme by the direct action of man, such that the heavy exploitation of their principal prey species may be an important factor. Viral or bacterial infections, perhaps due to pollution, have been implicated in die-offs of marine mammals in the Baltic and Mediterranean Seas (Heide-Joergensen *et al.*, 1992; Calzada *et al.*, 1994).

Apical predators, which include marine mammals such as some seal, dolphin and whale species, and large predatory fish such as sharks, tunas and halibut, played a role in controlling the densities of their prey species, but have also been among the first to be reduced in numbers by harvesting. However, given the complexity of many marine food webs, the commercial elimination of the main apical species often results in other organisms taking over part or all of the role of apical predator until, perhaps, they themselves are overfished (Kerr, 1977, Ursin, 1982) or change the composition of their prey (Glasser, 1978).

Marine food webs are complex (Caddy and Sharp, 1986) and pose difficulties in quantification of the impacts of human actions (May *et al.*, 1979). Not always has the elimination of an apical predator led to a major increase in the yield of its prey species (Pauly, 1979a). On the other hand, considering stock sizes of predator species prior to depletion, there would presumably have been a degree of competition between man and the apical predators for their common prey, if the latter were still present in their original numbers. Thus, a number of calculations (e.g. discussed in Katona and Whitehead, 1988) have shown that marine mammal populations, even though many are now reduced in size in many areas of the world, may still consume at least as much of some prey species as is harvested by man. It has been postulated that sperm whales alone, consume a greater quantity of squid than is harvested by the world's fisheries (Voss, 1973). Similar calculations are common in the literature. For the Bering Sea ecosystem, for example, in FAO (1978b) it was estimated that a (then) biomass of 450 000 metric tons of 25 species of marine mammals, could have been as high as 9-10 million metric tons annually: roughly four times the (then) commercial catch weight (but of course dominated by nekton and benthos species not exploited by man). More recently, concern has been expressed as to the impact of heavy fishing of Alaskan pollock on populations of their natural predators, such as the northern fur seal. Baleen whales, prior to the onset of whaling, were estimated to have required some 190 million tons of krill per year, or twice the weight of current world fish landings (FAO, 1992f).

Some seal populations are vectors for parasites, which also infect some commercial fish species such as cod (McClelland *et al.*, 1983; FAO, 1978b) and incidentally may cause damage to the gear of fishermen. This partly explains the antagonistic behaviour of fishermen in some parts of the world towards some marine mammals. Calculations have been made of the "loss" to the fishery, but it is not certain that such calculations represent real effects on the fishery. Nor can they be simplistically applied to the estimation of the "surplus" yield to man released by fishing down natural predators on fish. Such calculations do not take account of ecological linkages, ecosystem stability, or the growing appreciation of the ecological role of marine mammals and their cultural significance to man, due to their intelligence, means of communication and social behaviour. Most arctic and subarctic seal populations are now recovering to former levels and concern has been expressed that the impacts of large populations of harp seals, sealions and others (outside the Antarctic) on those resources harvested by man, may justify population control measures.

Current theories of the role of predators in ecosystems in terrestrial ecology have emphasized their importance in culling sick or unfit individuals, and keeping population sizes of prey species in balance with available resources, but hard evidence as to the extent to which this argument applies in the sea where human predation pressure is also high, is not easy to come by. It has not been confirmed in the marine environment whether with the reduction in populations of top predators, prey fish populations are more unstable, and/or whether a 'surplus' harvestable production can be estimated in excess of the needs of natural predator species competing for the same food. For example, the 150 million tons of Antarctic krill not being eaten by depleted rorqual whale populations are now being consumed by other species, some of which may have increased in population size (FAO, 1978b). It may be supposed that the return of many marine mammal populations to the numbers that existed prior to man's assumption of the dominant role as apical predator in marine food chains, would only be possible by, and would certainly result in, a significant cuts in overall global fish catch. Since food availability is one of the factors that limits predator populations, given the existence of industrial fisheries, this limitation is likely to come into play at lower stock sizes of marine mammals than formerly. This would not necessarily affect the sustainability of the marine mammal populations concerned, and, at least in theory, could be taken explicitly into account when catch levels are decided upon.

Clearly specious arguments are common in the conservation versus development debate, and not always is there an examination of the conflicting evidence on either side. It has been speculated that reducing the abundance of those cephalopods which feed on juvenile fish could increase fishery yields of conventional fish species. This argument does not take into account the growth in squid fisheries going on around the world, and that this could be due to cephalopods occupying part of the niche left by depleted groundfish species; nor the fact that squid may now command higher unit values than most fish. It is difficult to avoid the conclusion that one of the objectives of sustainable development of endangered stocks of unharvestable apical predators is their recovery to stock sizes that can reproduce themselves without danger of population collapse. However, uncontrolled population sizes of apical predators are not necessarily without adverse repercussions on the availability of fish for human food. Clearly, the return of stock sizes of some apical predators to former unharvested levels would only be possible at a considerable cost to man in terms of the loss of animal protein from the oceans. This must be taken into account in the context of **sustainable development** of marine resources as a whole.

In the case of the reduction in population size of apical fish predators, such as grouper, cod and halibut, some increase in yields from species lower in the food web may result, but since these yields are dominated by small forage fish which tend to be lower in unit value than the apical fish predators, the net value to the fishery is likely to decrease as a result.

Another important aspect of the management of apical predators is the possible accumulation, through food webs, of contaminants such as mercury organochlorines (e.g. Olsson, 1994), or even natural substances, such as ciguatoxins (Pulos, 1986), which may be a threat to apical predator species and a health hazard to the human consumer.

The principles of **sustainable development** require that marine resources be exploited in a way that ensures the continuity of populations and species, but they do not assist in making a choice between different levels of direct or indirect exploitation that otherwise satisfy these principles but result in different relative abundances of ecosystem components. Just what the level of exploitation should be has become a matter of controversy between those concerned with food security and those concerned to see populations of some species maintained in as close to an unexploited state as possible (Beddington and May, 1977; Beddington, 1978). Achievement of the latter objective will impose significant costs in terms of its impact on the nature and the extent of harvesting activities, and at present, this cost will have to be borne almost exclusively by the fishing industry which still plays the major role in terms of extracting rent from living marine resources.

### 2.6.1 Proposed Actions

The following actions are suggested as central with respect to the **sustainable development** of apical predators and endangered species:

(i) **More - and more intensive - investigation is needed of the role of marine mammals and other apical predators in marine ecosystems, their role in controlling prey populations, and their indirect interactions with man through the food chain.**

(ii) **The incidental catches of marine mammals, turtles and birds must be reduced, especially in the case of endangered species, and an effort made to maintain these incidental catches at levels allowing resource recovery.**

(iii) **The harvesting of marine mammals for food, through deaths incidental to harvesting, or for other reasons such as predator control within EEZs, should recognize that these populations have a slow rate of replenishment, are susceptible to other types of interference by man, and have non-consumptive uses.**

## 3. SHORT-TERM AND LONG-TERM VARIABILITY IN THE MARINE ENVIRONMENT

Species with a relatively short annual breeding season tend to show more dramatic seasonal variations in numbers. The abundance of "perennial" species, such as most large fish, also depends on biotic factors and environmental changes that effect recruitment. For longer-lived commercial-sized marine organisms, variations of at least an order of magnitude usually occur in recruitment over a period of several years (Ricker, 1975; Beverton and Holt, 1957). These changes in level of recruitment from year to year due to environmental changes are often exaggerated due to their influence on the level of harvesting and fleet size following years of peak earnings. Such a 'lagged' effect accentuates year to year changes in the level of landings (see Caddy and Gulland, 1983 and Fig. 7).

The most important of these factors and changes tend to operate early in the life history of the fish (Cushing, 1982, 1988). For example, the survival of eggs and larvae is particularly sensitive to ecological factors, and recruitment of surviving young fish to the adult or fished stock is often related to marine weather patterns, oceanic conditions, the size of the broodstock (and, to close the circle), to fecundity, spawning success and other factors.

Short-term (seasonal) and long-term (interannual to decadal) **environmental variations**, producing comparable variations in abundance of sardines and other species (Lluch-Belda *et al.*, 1992), preceded the influence of man (e.g. Cushing, 1990; UNEP 1994). They must, nevertheless, be taken into account to achieve **sustainable** - and optimal - **development**.

Long-term variations in the marine environment due to **climate change** have been documented and changes in fish abundance have been correlated with them. For example, it is known from fish scales in cores of bottom sediments that different species replaced each other even prior to man's influence on marine ecosystems (Holmgren-Urba and Baumgartner, 1993). Also the "little ice age" in the Northern Hemisphere during the early Middle Ages, apparently caused by abnormalities in the sunspot cycle, was a period during which cod populations off Greenland declined and were replaced by seals and other fully Arctic species.

The foregoing type of considerations must be taken into account in evaluating changes in the oceanic environment due to human activities. The amplitude and pace of the expected global climate changes (see section 5.10) will be superimposed on an already wide natural variation in conditions, and it is therefore difficult to forecast their effects on fisheries and aquaculture. Although particular stocks may be adversely affected, large changes in total marine fish production are not expected.

Changes in rainfall patterns, river run-off and sea-level rise will especially affect life in enclosed and semi-enclosed seas, coastal wetlands, estuaries, lagoons, mangroves and other important coastal nursery areas. Land erosion may increase, leading to coastal siltation, reduction of the marine photic zone and further degradation of coral reefs and sea-grass beds.

Coastal aquaculture will also be affected, especially in southeast Asia and India from where most of the world's marine and brackish-water aquaculture production now comes. The cost of moving and rebuilding coastal aquaculture infrastructures and resiting seaweed and mollusc beds cannot be calculated at present but would be enormous.

The WMO-UNEP Intergovernmental Panel on Climate Change has made a comprehensive scientific assessment of climate change (IPCC, 1992); some of its findings are considered in section 5.10.

There are limits to what can be done to mitigate future adverse effects of climate change without the full support of governments and ofpeople in the areas at risk. Financial consequences are still hard to predict and it is difficult to convince governments and institutional donors to commit funds until better forecasts are available. Premature, ill-informed decisions could be costly and dangerous but there is also a risk in taking no action at all. It is important to reduce the present level of uncertainty.

## 4. THE OPTIMUM HARVESTING OF LIVING MARINE RESOURCES

### 4.1 FISHERY MANAGEMENT OBJECTIVES

Generally speaking, experience with the fisheries of northern latitudes and upwelling systems has shown that moderate levels of exploitation (fishing mortality), relative to the natural mortality the fish resource population is adapted to, will not usually affect the capability of that resource to regenerate itself in the medium to long term. This may also be true even if the species and size composition are somewhat modified from that occurring under "virgin" conditions, as is usually the case with moderate to high levels of exploitation. Perhaps this is because such systems are mostly inhabited by species with unspecialized feeding habits, that can respond in a rather elastic fashion to changes in abundance of one or another of several main prey items. The reproductive mode of such species tends to be based on broadcast spawning with large numbers of eggs dispersed widely throughout the stock area, of which only a very tiny proportion need to survive to ensure stock replenishment.

In contrast, many tropical marine communities are much "older" in evolutionary terms and are dominated by more specialized species adapted to certain specific food items and habitats; in such communities, in which environmental extremes are less common than in, say, polar ecosystems, there are more but less abundant species. These communities may be more susceptible to serious ecological stresses, including overfishing. For these resources, emphasis may need to be given to zonation and non-exploitive development as well as harvesting.

The need to conserve options for future generations incorporated in the concept of sustainable development, has been a goal of fisheries management for decades. To what extent have the approaches used to date been successful? Some explicit current approaches in marine fishery management are, *inter alia*, Maximum Sustainable Yield (MSY) and Maximum Economic Yield (MEY), referring, respectively, to the maxima in terms of physical yield and of net economic value and social benefits, derivable from a given resource (Panayotou, 1988).

The concept of MSY is used in the UN Convention on the Law of the Sea as the main benchmark for optimal exploitation; it becomes clear, however that "single-species MSY" criteria have several drawbacks in terms of **sustainable development**. The latter will require other benchmarks based on whole-ecosystem criteria, since one of the key features of marine ecosystems is their "interconnectedness" (Apollonio, 1994) (see Annex I). A serious reduction in the abundance of a "target" resource as a result of heavy exploitation can change the relative abundances of all the species in the marine fish community, since they are linked to the target species in question, as competitors for food, breeding space, adequate environmental conditions etc. This change in relative abundance is not necessarily a cause

for concern, as long as the species involved do not fall below the level at which the stock is endangered, and the system retains the flexibility to return to its original condition once exploitation is reduced, within a reasonable time period. From this multispecies perspective, the MSY concept makes no allowance for interaction between species (predator/prey equilibria, for example), or for whole-system effects such as a decrease in the stability of the system (fishery-stock-ecosystem), and while it is applicable to a simple, single-species fishery, its applicability to a fish community, or a multi-species fishery as a whole, is much less obvious (Caddy and Mahon, 1995).

Particularly where a species is a target of exploitation, its capacity to replace itself through reproduction may be reduced in the presence of competitor species (not always of commercial value) which can partly displace the depleted species from its place (ecological niche) in the marine community, and lead to a different proportion of each species spawning than originally present. The target species may be an important food item for other species, so that the abundance of other members of the food web are affected by its intensive exploitation. The extent to which this new population equilibrium can sustain itself differs from system to system, and the question of stability, important preliminary preconditions in deciding between the feasibility of different **sustainable development** strategies for each of the systems concerned.

In practice, unfished populations are normally dominated by large, old fish with slow growth (that add little biomass per unit time for a given consumption of food resources). A moderate level of fishing increases the production of new biomass by removing old fish and thus making room for younger fish, for which the rate of increase in biomass due to growth and reproduction exceeds losses due to natural. However, an increase in fishing effort (and therefore investment in fishing capacity) yields progressively smaller increases in biological production, until some point of Maximum Biological Production (MBP; Caddy and Csirke 1983) for the stock is reached, when the stock is making its maximum combined contribution both to natural predators and to the fishery. Total production, supporting predators and man, declines with further increases in fishing effort. Even though landings may subsequently increase slightly, it is now at the expense of other components of the ecosystem. Fishing at the level of effort that yields the MSY may result in an excessive reduction in mean size, mean age and catch rate for the target population, and will reduce the number of times an adult organism reproduces in its life history, thus making the stock more susceptible to the effects of environmental fluctuations on breeding success.

It should be noted (Garcia, Gulland and Miles, 1986; Sissenwine, 1978) that MSY, as for other practical management reference points, requires good fishery data to be collected, but MSY also requires to be exceeded, such that the overall catches begin to decline, before it can be properly defined. This leads the fishery into a state of overexploitation which is not easily reversible (e.g. FAO, 1994a). MSY as an overriding objective of fishery management also exceeds the effort level equivalent to the maximum economic yield, and a number of other socially desireable objectives. Certainly, the extra cost of fishing required to move from MEY to MSY can hardly be justified (FAO, *op. cit.*). Attempting to define the level of fishing effort at which the MEY can be achieved has its problems, especially if competing fleets are involved, since the appropriate fishing effort varies with the changing costs of fishing and fish prices.

It has been found that, for some fisheries, the MSY target can also lead to population collapses, since, as is often the case, the current state of the resources is not accurately known, and effort "overshoots" can easily occur. As a broad generalization, achievement of the Maximum Biological Production (MBP), the spawning stock biomass that maximizes

recruitment, or the MEY, all imply lower rates of exploitation than the MSY target, which corresponds to a higher degree of capitalization of the fleet than is justified by the rapidly diminishing extra returns per unit extra cost when moving from the lower rates of fishing implied by the MEY towards those implied by the MSY.

The response of the ecosystem to moderate exploitation may be more stable when fishing effort and death rate due to fishing remain more or less constant, despite natural fluctuations in abundance, than with a constant harvest but wide variations in the rate of harvest. Stability may also be improved when fishery removals for each species in a community are adjusted to be a similar proportion of the natural deaths due to the predation each species suffers from. (Large species with a low natural death rate can sustain much smaller rates of removal than small ones, and other species with a high death rate.)

Experience has shown (FAO World Conference on Fisheries Management and Development, 1984) that the major economic gains from harvesting wild resources come from ensuring that harvesting capacity does not exceed the capacity of the resource to sustain this harvest while reproducing itself. At the same time, reducing costs and wastage during the phases of capture, transformation and transportation, ensuring substitution of imported products by those locally available, maximizing the value of the transformed products, as well as reducing unnecessary capital expenditures on fishing vessels and other equipment surplus to the potential economic yield, are all goals that yield major economic gains in the long run. Experience has also shown that neither the physically (MSY) nor the economically (MEY) optimal harvesting rates are stable "end points" of development, and that in fact the only "meta-stable" point in the system is when expenditure on harvesting equals the economic return from fishing; i.e., a zero-rent situation. It is evident, therefore, that an active research and resource monitoring capability and an associated control and surveillance capacity are essential components of sound fishery management.

The setting of objectives for fishery development and management should be based, *inter alia*, on an assessment of the fishery resources available, the capacity of the primary and secondary sectors, the markets to be satisfied, and the socio-economic context in which the development is to be achieved, in particular the impact of any new development on traditional fishermen. Sometimes, the objectives are multiple and not always compatible, and difficult choices may have to be made; it is therefore important that the objectives be explicit and their relative advantages made clear. Moreover, since the conditions in which fisheries are conducted are dynamic, objectives appropriate at one stage may not be so at a later stage; hence periodic evaluation of the validity of objectives is necessary. The difficulties of setting either total allowable fishing effort or catch are due to, *inter alia*, the variability of the resource and the effect of fishing pressure on it, and the relative difficulty of controlling and/or enforcing either total allowable fishing effort or catch, especially if other (foreign) fishing fleets are exploiting the resource of concern.

Fishery management should be conceived and understood not as a constraint upon rational exploitation (i.e., sustainable development) but as an essential tool for such development. Nevertheless, it can only hope to be successful if, apart from the careful definition of objectives mentioned above, those authorities mandated to pursue such objectives (i.e., to manage the fishery) have well defined lines of responsibility and accountability, and work in close co-operation and communication with the fishing industry.

## 4.2 DESTRUCTIVE FISHING PRACTICES AND OVERFISHING

### 4.2.1 The effects of fishing gear on the ecosystem

Trawling and dredging can affect the marine environment by, for instance, destroying organisms of the sea bed or sea-grass meadows by mechanical disturbance and siltation. Illegal fishing techniques such as the use of dynamite or chemicals to capture reef fish also damage the habitat (Alcala *et al.*, 1987; Maclean, 1988). These matters should be handled through legislation with at-sea enforcement, and by enlightening fishermen as to the longer-term negative consequences of using destructive fishing methods.

Intensive fishing modifies the abundance, age structure, species composition and potential for reproduction of fish stocks. Moderate levels of exploitation remove old, slow-growing individuals and reduce the abundance of large predators thereby increasing the productivity, hence the sustainable yield, of the remaining stocks. High levels of exploitation may reduce to "commercial extinction" the abundance of older mature age classes and of large, slow-growing species in general. Although very few cases of actual species extinction by fishing alone have been documented, intensive fishing reduces genetic diversity of the species concerned.

The fact that fishing gear and methods of fishing are generally aimed at a marketable size of fish in some fisheries has not prevented capture and discard of considerable quantities of species and sizes that, with further development, could be marketed as a valuable source of protein. In recent years, public concern about the so-called "by-catch problem" has been directed particularly towards intentional or incidental capture or entanglement of marine mammals, birds and turtles by operative fishing gear, or its accidental capture by lost or discarded fishing gear; so-called "ghost" fishing (Breen, 1989). Reducing such incidental captures to the minimum should be aimed at by improved gear design and fishing practices. Synthetic netting materials do not break down; moreover, such netting may continue to attract and trap animals approaching to feed on animals already captured in it. In fact, the level of global discardings (Alverton *et al.*, 1994) estimated at 27 million tons, is a significant proportion of the global marine catch.

However, fishing by trawling, drift netting and seining, even when carried out with improved gear in a responsible fashion, will inevitably capture non-target species in small numbers. Some types of fishing gear cannot readily be substituted and cannot always be suitably modified to meet excessively rigorous criteria. Application of unduly restrictive norms may therefore bring many forms of commercial fishing, whether large-scale or artisanal, to an end. The hardship thus caused to human coastal populations in general, and to fishing communities in particular, especially in developing countries, must be taken into account in applying such conservation measures, if in fact the problems could be greatly reduced by a reduction in fishing effort or areas/seasons fished.

### 4.2.2 Fleet Expansion and Overcapitalization

A major geographical expansion of the range of action of fishing fleets, which even prior to the UN Convention on the Law of the Sea were operating in all world oceans, has taken place over recent decades (FAO, 1992e). In the same period, developing coastal countries have seen their wild marine resources exploited first by foreign distant-water fleets and, more recently, by national fleets sometimes through joint ventures between coastal States and distant-water fishing nations. Whatever the strategy of exploitation followed, a system of resource monitoring is an essential component of the national fishery regime. Experience has shown that high levels of exploitation not only promote the dominance of less

valuable species in the catches at the expense of valuable target species, but lead to inefficient use of specialized equipment to catch and process fish. This often has to be purchased by developing countries with hard currency. Hence, uncontrolled development adversely affects net export earnings and foreign exchange reserves, as well as increasing the instability of marine resources. A healthy resource base can be maintained by rigidly controlling fleet development. We may note that high operating costs (for fuel etc.), in theory, can place a brake on over-investment. By contrast, fuel subsidies for marine fisheries tend to have the opposite, negative effects on the resource base, and reduce options for **sustainable development**.

## 4.3 STOCK RECOVERY AFTER OVEREXPLOITATION

The ability of a marine resource to recover its pristine abundance if exploitation ceases for a medium to long period of time is generally assumed. For example, following the two World Wars, when fishing ceased in the North Sea, this assumption proved to be substantially justified (Beverton and Holt, 1957). There has also been a recent major recovery of the Peruvian anchoveta resource, after a collapse due to heavy fishing and environmental change in the 1980's. Environmental influence appear to play a predominant role for resources in upwelling areas in which stock fluctuations are naturally high. It should be borne in mind that, for many small pelagic fishes, notably sardines and anchovies, the effects of these periodic changes in favorability of the environment persist even when the absolute abundance itself varies, as may happen under intensive fishing. The capacity for stock recovery after over-exploitation may therefore not be simply explained by reduced fishing pressure, but may also require favourable environmental conditions.

In contrast, in the case of some complex tropical biological communities, heavy fishing may change species composition dramatically, and it is less certain whether the reversibility of degraded communities is likely, at least in the short term. For example, removal of grazing fish from coral reefs or run-off of sewage from shore can lead to blanketing by algae and to death of the living coral that provides the necessary substrate for reef fishes. Reverses to this trend may not automatically occur in the short term once the damaging impact is removed.

## 4.4 RESPONSIBLE FISHING

### 4.4.1 General Considerations

The most reliable generalization in the theory of fishing appears to be that, under unlimited access to resources and fishing grounds, a "boom and bust" situation results, with periods of overexploitation resulting from uncontrolled investment in fleets, and strong depletion, leading eventually to vessels moving to other fisheries or being retired, with (hopefully) a stock recovery initiating another cycle of investment. Some of the features of such a sequence of events are shown in Figure 10. Obviously, the possibility of such a "cyclical" phenomenon has serious implications for the resource, the fishing industry, and the communities dependent on them. Perhaps fortunately for many living resources, in the past, the "break-even" catch rate that corresponded to a "break-even" economic yield, particularly in a period of increasing fuel costs, has often been low enough to allow stock recovery. Two contrasting factors now threaten the possibility of achieving optimal usage of resources: growing coastal populations, with their needs and their impact on the coastal environment; and new improvements in technology, cheaper fuel, vessels and equipment. Larger, more efficient nets, more-seaworthy vessels, with better position- and fish-finding equipment, allow this economic break-even point at which fishing ceases to be profitable, to be reached at

progressively lower levels of resource abundance. These largely undocumented effects threaten the renewability of many resources and places an onus on the need for strict management control, monitoring of technological changes and the specific allocation of rights of access.

An optimal harvesting strategy for "wild" resources needs continual adjustment on the basis of monitoring and research in a variety of fields and is only possible, sustainable and ecologically sound, at a level of harvesting that yields considerably less than the maximum that the resource is able to provide during the first decade of unrestrained fishing. Such evidence as we have on the age composition of fishing fleets (e.g. Caddy 1993b) suggests that a steady investment in fleet capacity from year to year, may be less typical than 'pulses' of new fleet capacity entering a fishery over a short period, which greatly complicates management and contributes to non-equilibrium conditions.

One other practical aspect of sustainable development is the application of more selective fishing gear and methods. By-catches of non-marketable or undersized fish or of non-target species (birds, mammals) are not wanted by the fishermen, but fishing gear and methods are rarely fully selective and fishermen dump what cannot be sold. For instance, the by-catch from shrimp trawling alone is probably in excess of 5 million tons annually (Alverson *et al.*, 1994).

**Technical advances in fishing gear and fishing methods** very often lead to a breakdown of traditional management systems for which modern management systems have not successfully substituted. The need for appropriate allocation of marine space and resources, with direct community participation in the decision-making, is vital to the achievement of sustainable development.

The International Conference on Responsible Fishing (Cancún, Mexico, May 1992; FAO, 1992c) adopted the Declaration of Cancún. This Conference, *inter alia*, requested FAO to prepare an International Code of Conduct for Responsible Fishing, taking the Declaration into account. The main elements of such a Code were discussed at the FAO Technical Consultation on High Seas Fishing and are proposed in (FAO, 1993c); it is likely to cover: fishing operations (e.g., deployment of fishing vessels and gear, navigation regulations, vessel and gear marking, trans-shipment of catches, certification and crew training, fishery patrol and protection, flagging); fishery management; trade in fish and fish products (stressing the importance of harmonizing environmental measures with the maximizing of trade); fishery research (see section 6, below); aquaculture development (with particular attention to the relation between the culture and the natural environment and its wild resources); and the inclusion of coastal fisheries into integrated coastal-area management schemes. (Extracts from the text of the Cancún Declaration are provided in Annex V).

It should be recalled that the question of, and need for, such a Code of Conduct was first raised at the Nineteenth Session of the FAO Committee on Fisheries (Rome, April 1991), and the FAO Technical Consultation on High Seas Fishing (Rome, September 1992) supported the proposal for the elaboration of such a code; some preliminary outlines for which are already emerging (FAO, 1995a).

Regulation of fishing gear specifications, and the enforcement of minimum allowable individual fish size in the catches of targetted species, seek to compel fishermen to modify mesh size and to deploy fishing gear so as to control the sizes caught, but few if any such regulations refer specifically to gear selectivity for species. There is an urgent need for further research on more selective fishing gear with respect to species as well as sizes, and a better understanding of the appropriate areas and seasons when undesirable by-catch is minimized.

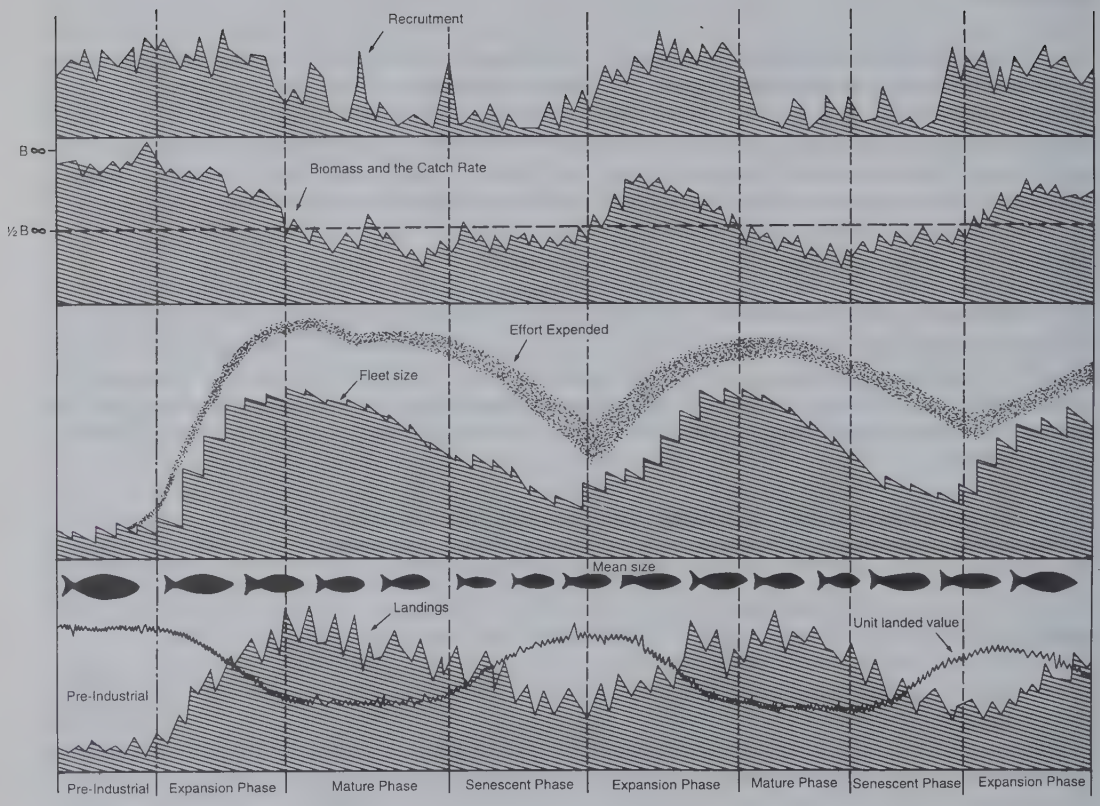



**Figure 10.** Phases in an idealized fisheries 'cycle' for an open access resource; assuming successive periods of investment in catching capacity, fishing effort and landings, biomass and consequent recruitment and mean landed size (from: Caddy, 1984)

Some States have already introduced legislation controlling fishing methods, and making escape devices obligatory in certain types of fishing gear. This has often led to conflict between fishermen, administrators and the public, but further development of escape devices for small fish, and the use of biodegradable components of gear so as to avoid "ghost fishing" by lost nets or traps, are important and need greater support. To prevent illicit disposal of damaged nets, methods for filament marking are being developed that enable the net's origin to be traced.

Fishery resources contribute to **national food security** as coastal States aim at obtaining production of adequate supplies, of sufficient quality, to ensure a healthy life for their populations. Fish in the diets of persons living in many developing countries is often

critical for their nutrition, and coastal populations may obtain much of their animal protein intake from fish (FAO 1991a, 1995c, d). This is especially true in Asia, where over 1 billion people depend heavily on fish for their animal protein. World consumption of fishery products is very variable, and average figures are relatively meaningless, but since supply is comparatively constant and prices are generally rising in industrialized countries, we may expect an increased flow of fish from developing to developed countries in the future (FAO, 1993b). This will have serious consequences since consumption of fish is perceived to confer health benefits as a supplement to low-protein foodstuffs, allowing, in particular, the normal development of children otherwise dependent on a carbohydrate diet. Many developing countries import significant quantities of processed fish with hard currency, and a policy of import substitution by local fishery products available within the national EEZ, a higher valuation of national fishery resources, and more effort allocated to their management, will all have positive effects on the economy, whether fish is used for food or export.

It has been anticipated that the shortfall in world fish production by the year 2000 will be at least 20 million tons, and this does not take into account the potential for collapse of many fisheries that currently provide much of the world's production and which are currently fully fished or even overfished (FAO, 1993g, 1995c). The consequences of a collapse in fishery production would be a likely increase in the real prices for marine products, but, of far greater importance, will have dramatic repercussions on the lives of millions of the poorest people; this greatly constrains the options available for the management of aquatic resources. The above-mentioned shortfall does not take into account the current conversion of roughly a quarter of the global marine production (especially that of small pelagic fish) into meal for livestock feed; a similar amount to the anticipated shortfall in "fish for food". This conversion of fish to meal reflects the established demand for animal feed as well as difficulties handling and commercialization of large volumes and seasonal fleets of many small pelagic species for human food. The extensive use of animal protein for livestock feed nevertheless constitutes a significant loss of assimilable protein to human diets, and the further development and transformation of small pelagic fish for food should alleviate the plight of the poorest and generally increase the economic return to fishermen.

Regarding the effects of market demand on sustainable development and conservation of resources, the existence of a demand for a resource, information on its availability, and the absence of constraints on its marketing and trade, are all positive factors encouraging sustainable development in industry and agriculture. However, in the exploitation of renewable natural resources in the absence of a management system pressures for entry to the fishery lead to a surplus of fishing effort. Thus, if there is no resource management framework in place, all of these otherwise positive factors can unwittingly facilitate stock collapse. The transition from traditional use of natural systems to uncontrolled industrial use is a dangerous period for coastal States utilizing "wild" resources, as has also been observed in the forestry and the wood-products industry.

Centralized political systems and market-oriented economies can both lead to over-exploitation of the resources of natural systems, but for rather different reasons. The efficiency of a free market system stems from the fact that it minimizes the knowledge required for efficient economic decision-making, on the grounds that each individual in the chain of individuals between production and consumption should be free to follow his or her self-interest. This however dilutes the responsibility for the side effects of resource exploitation as a whole, and for the effects on the environment, which can be either at the production end (e.g., overfishing) or at the consumption end (e.g., pollution). In contrast,

centralized systems remove individual and local responsibility for decisions, and weaken local control and concern for the environment. It would seem therefore that the need for overall control of the conditions or rules under which marine resource exploitation takes place is independent of the particular political framework that applies.

It seems important that in the future, limitations on access and removal not be dictated solely by market value and demand, especially from the global market place, which is progressively less likely to be saturated for many fishery products. The negative impact that high demand may be having on the state of resources is of special concern for developing countries, where inadequate controls on access and removals exist. Here, the opportunity to provide "added value" by processing, quality control and sophisticated marketing, should be used to reduce uncontrolled export of primary commodities which reflect only a fraction of their eventual retail values on the markets of developed countries. Naturally, foreign-exchange earnings are a high priority for developing countries, but a proper calculation should include consideration of food security and the cost of replacement of national protein resources. One example is the trend to high-intensity harvesting of "trash fish" for shrimp feed in areas that formally yielded high-diversity, high-unit-value fish for local markets through a low-intensity, diversified artisanal fishery.

Market demand has also been considerably enhanced by the significant growth of many human populations, by their tendency to move from rural and agricultural areas to large (and growing) cities and, in particular, to the coastal zone. These movements remain largely uncontrolled and place severe strains on marine (and often other) resources, which are still largely regarded as common property with open, cost-free access, often aggravated by uncontrolled human pressures on aquatic environments in general.

### 4.4.2 The Precautionary Approach

Principle 15 of the Rio Declaration of the UN Conference on Environment and Development (Rio de Janeiro, 1992) states that *"In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation."*

In cases of high uncertainty about critical areas or species, in particular, and to avoid potentially irreversible changes, the **precautionary approach** has been advocated to make development conditional upon scientific proof of its harmlessness, and this principle is now being extended to management of fisheries ecosystems (e.g. Garcia, 1994a, b; FAO, 1995g).

Although in absence of adequate data to setting exploitation levels, a precautionary approach is desirable, this approach should, where possible, be such as to encourage accumulation of data on which a more information-based management approach could be based. The mere existence of known links between different species in the food chain may not be, for example, an "appropriate and sufficient" cause for banning controlled exploitation which, if accompanied by pilot-scale fishing and properly planned shipboard data-gathering exercises, could yield much more precise indications of actual as well as potential impacts. Judging from experience acquired to date, the impacts of fishing on the food chain may be quite different from those expected. The most practical precautionary solutions offered to date, seem to be either to establish a low rate of exploitation based on reference point(s)

## 1. THE PRECAUTIONARY APPROACH TO FISHERIES AND THE BURDEN OF PROOF

11. Within the framework outlined in Article 15 of the UNCED Rio Declaration, the precautionary approach to fisheries recognises that fisheries systems are slowly reversible, proorly controllable, not well understood, and subject to changing human values.

12. The precautionary approach involves the application of prudent foresight. Taking account of the uncertainties in fisheries systems and the need to take action with incomplete knowledge, it requires, *inter alia*:

    a. consideration of the needs of future generations and avoidance of changes that are not potentially reversible;
    b. prior identification of undesirable outcomes and of measures that will avoid them or correct them promptly;
    c. that any necessary corrective measures are initiated without delay, and that they should achieve their purpose promptly, and that they should achieve their purpose promptly, on a timescale not exceeding two or three decades;
    d. that where the likely impact of resource use is uncertain, priority should be given to conserving the productive capacity of the resource;
    e. that harvesting and processing capacity should be commensurate with estimated sustainable levels of resource, and that increases in capacity should be further constrained when resources productivity is highly uncertain;
    f. all fishing activities must have prior management authorization and be subject to periodic review;
    g. an established legal and institutional framework for fishery management, within which management plans that implement the above points are instituted for each fishery, and
    h. appropriate placement of the burden of proof by adhering to the requirements above.

13. Key concepts in past discussions of the precautionary approach have been the burden of proof and the standard of proof (i.e., the responsibility for providing the relevant evidence and the criteria to be used to judge that evidence). Often, the precautionary approach has been taken as requiring a reversal of the burden of proof, such that human actions are assumed to be harmful unless proven otherwise. In regard to these concepts, it is recognised that:

    a. all fishing activities have environmental impacts, and it is not appropriate to assume that these are negligible until proved otherwise;
    b. although the precautionary approach to fisheries may require cessation of fishing activities that have potentially serious adverse impacts, it does not imply that no fishing can take place until all potential impacts have been assessed and found to be negligible;
    c. the precautionary approach to fisheries requires that all fishing activities be subject to prior review and authorization; that a management plan be in place that clearly specifies management objectives and how impacts of fishing are to be assessed, monitored and addressed; and that specified interim management measures should apply to all fishing activities until such time as a management plan is in place, and
    d. the standard of proof to be used in decisions regarding authorization of fishing activities should be commensurate with the potential risk to the resource, while also taking into account the expected benefits of the activities.

(excerpt from FAO, 1995g)

below the MSY level (e.g. Caddy and Mahon, 1995), or to set up criteria for amounts and areas of harvesting of a pilot fishery, during which intensive data collection by observers on board fishing vessels could allow evaluation of the impact of different fishing methods, and gather the relevant data.

### 4.4.3 New Options for Sustainable Harvesting

For marine resources as a whole, experience over the last few decades suggests that the number of important unexploited resources for which entirely new fisheries are feasible may be rather limited. Squids and mesopelagic fish (Garcia and Majkowski, 1990) are the main resources for which potential may still exist. For mesopelagic fish, potential yields could be high, but the net return on investment, given currently low unit values, high costs of fuel and the high level of harvesting technology required, may not be as great as some projections suggest.

The primary potential of mesopelagic fish is to replace larger proportions of small pelagic fish, such as sardines, sprats and anchovies, in the production of fish meal, thus potentially releasing the aforementioned small pelagic fishes for direct use as human food. This possibility depends on technological and marketing solutions being found and is urgent, given that demand for marine products is progressively exceeding supply and is taking fish protein beyond the reach of the poor. In this case, the possible impact on other species in the oceanic food chain must be taken into account. The major opportunities still open for the sustainable development of most marine resources may lie in the reduction of wastage (e.g., that of finfish by-catch in shrimp fisheries in the tropics), and in allowing recovery of heavily fished resources to more productive levels, as is now being attempted by the new government of Namibia in its Exclusive Economic Zone, and in enhancing the quality of fish products by adding "value" to certain fish products prior to marketing and export.

Other resources, formerly considered underexploited include Antarctic krill, now apparently a slower-growing and longer-lived species than was believed formerly to be the case. Further exploitation is dependent on establishing a sustainable impact of fishing on other living marine resources of the Antarctic which depend on this species for food, even if this leads to some reduction of their long-term population levels. Here, as for high-seas resources, there is a need for risk evaluation that weighs possible adverse impacts against tangible benefits, and for decisions to be taken on the equitable allocation of these benefits. Similar considerations have been raised in the North Atlantic about the advisability of heavy exploitation of small forage fish, such as sand eels and capelin, that are essential food for more valuable species such as cod, and for species under conservation, such as some sea birds (ICES, 1994b). In this case, the explicit requirements of predatory fish, or of sustainable populations of marine mammals and sea birds that feed on these resources, need to be given consideration.

Currently most feasible options for increasing the world fish catch may be summarized under the following seven headings:

(1) **New "wild" resources**: Large untapped marine resources are very restricted in number, and their current exploitation may be inhibited by technical or economic factors, but include principally mesopelagic fish, small crustaceans and cephalopods. Their exploitation must be undertaken with an understanding of their linkages to other organisms of social/biological importance, may require appropriate new technology, and pose problems in transformation, marketing and equitable allocation.

(2) **Reduction of waste**: Large proportions of edible by-catch in fishery operations are lost, either through being rejected at sea (e.g. Crean and Symes, 1994; Alverson *et al.*, 1994), in storage, or during transformation and transport. This problem offers the greatest potential for immediate application of appropriate technology in all sectors. Another aspect of waste reduction of economic importance relates to the use of fuel-efficient fishing vessels (e.g. Buxton and Robertson, 1989).

(3) **Elimination of waste in financial resources**: This offers perhaps the largest potential of all, given that fishery yield (physical and economic) declines above a very limited level of investment. Systems of controlling effort by limited licensing of vessels should, in theory, resolve this problem, but require costly involvement of governments in monitoring, research and control and surveillance. Systems of allocating harvesting rights to communities and/or the private sector will allow economic efficiency to be attained (e.g. Gimbel, 1994), and permit legal redress against infringement of user rights by excess fishing or by pollution. We may note that some financial resources released from construction of excessive investment in the harvesting sector, should ideally be diverted into stock enhancement, habitat restoration, and technologically improved methods of monitoring, control and surveillance.

(4) **Promotion of community development can lead to product diversity**: A more equitable sharing of benefits from the exploitation of marine resources in the context of limited access will contribute to the well-being of coastal communities and encourage diversification of products and resource use. The example of Japanese community-based coastal fisheries indicates that this is a feasible and desirable objective that will place emphasis on artisanal fishery vessels equipped with appropriate technology (Nagasaki and Chikuni, 1989).

Community-based resource development, with individual rights eventually reverting to the community and re-allocated in proportion to potential yields, encourages an appropriate mix of marine resource use and land-based activities such as small-scale farming, sports fishing and eco-tourism.

(5) **Restoration of degraded ecosystems and depleted resources**: To restore them to their full economic potential will be expensive, but will yield major economic returns. This will be essential in the case of, for example, semi-enclosed seas, lagoons, estuaries, reefs and mangroves, and will require actions by other sectors of the economy, and in the inland MCB discharging into coastal waters.

(6) **Marine aquaculture**: The potential for this sector in inshore and local enclosed marine waters is seen as less of a panacea in the recent past; degradation of these waters and effects of high stocking levels have made themselves adversely felt. Its role in relation to food security by increasing fish yields is not unlimited, given that most currently cultivated marine finfish are predators and convert fish and other protein-rich meals to cultured fish. This is not true for plankton- and detritus-feeding molluscs such as mussels, or for seaweed (Doty *et.al.*, 1987), whose cultivation offers great potential if markets can be found for these products.

(7) **Non-exploitive uses**: Growing interest in the marine environment and its living resources can lead to economic benefits from eco-tourism, marine parks and aquatic activities. These will place a high premium on unpolluted and locally pristine environments, such as those contained, for example, in biosphere reserves (e.g. Batisse, 1990).

Some futuristic possibilities that are beginning to emerge from current technological and scientific investigations may also be suggested here. Most are untried and will require vigorous feasibility testing, with emphasis on economic cost-benefit analysis before large-scale application.

(8) **Enhanced productivity**: "Seeding" of offshore areas by nutrients such as iron currently limiting oceanic productivity will promote phytoplankton growth and biological productivity. Similarly moderate levels of fertilization inshore may increase yields. In some circumstances, after careful evaluation, these mechanisms might be translatable into harvestable yield and might assist in fixing atmospheric carbon, thus contributing to a reduction of the "sierra" effect.

Offshore plumes produced by, for example, Ocean Thermal Energy Conversion (OTEC) systems (GESAMP, 1984a, b; Avery, 1994), could promote ocean productivity local to the point of discharge, as well as adding to energy supplies. Disposal of selected biodegradable wastes away from shelf areas may act in a similar way and possibly reduce coastal eutrophication.

(9) **Offshore aquaculture**: The technology for offshore aquaculture is now being developed. The main limitation again is foodstock. Some experiments now underway on the use of algal growth on structures suspended in oceanic waters have suggested that commercial herbivorous organisms (e.g. crabs) may be reared on these structures.

(10) **Biotechnology**: Biotechnology and the growing exploitation of biological diversity and genetic resources are applications that are just beginning but have the potential to make a significant economic contribution.

(11) **Large-scale artificial reefs**: The potential for increasing yield of high-value reef species by increasing surface relief (ruggosity) of shelf areas has been tested with different degrees of success (GFCM, 1990). Whether it is economically feasible to extend such structures over large shelf areas and the extent to which they enhance production remains to be seen. This application will only be economically attractive with assignment of specific user rights.

## 5. IMPACTS ON FISH STOCKS OTHER THAN THOSE DUE TO FISHING

Until quite recently, man's impact on marine ecosystems has been considered as largely restricted to the effects of fishing. The capacity of the marine environment and living resources to absorb the effects of other human activities has been considered effectively unlimited. To a certain extent, this has been due to the difficulties of documenting effects in an opaque medium. It seems that, as for terrestrial and inland aquatic ecosystems, some marine ecosystems have shown resistence to ecological impacts, whereas others are particularly sensitive.

Before considering how the concept of **sustainable development** applies to living marine resources, it is important to recognize that "development" (not necessarily sustainable) affects resources in two main ways:

(1) In the broadest sense, all harvesting of living organisms, whether whaling, the mining of coral reefs for structural materials, or the cutting of marine algae, can be considered as "fisheries", and this term encompasses harvesting of living organisms for food or for other purposes, from estuaries and intertidal regions to the high seas. Fishery development therefore encompasses the impacts of harvesting on all components of the marine food web.

(2) Changes in environmental conditions as a result of other human activities falling under the heading of "development" in the classical sense also affect living resources, which are also best considered under two main headings:

(a) those activities taking place within, or directly adjacent to, the marine environment, such as coastal development, shipping, at-sea dumping, coastal tourism, undersea mining, and gas and oil extraction;

(b) those outputs from human activities inland that affect MCB's via riverine transport (e.g., transport of products of land erosion, nutrients, pesticides, metals and other toxic materials), or via atmospheric transport of materials (e.g., organochlorines, some heavy metals: see e.g. Ackefors *et al.*, 1990).

## 5.1 MARINE POLLUTION

Various definitions of marine pollution need to be taken into consideration in discussing various man-induced effects on marine resources. Several have been proposed:

GESAMP (1983) defined pollution as:

*"the introduction by man, directly or indirectly, of substances or energy into the marine environment (including estuaries) resulting in such deleterious effects as harm to living resources, hazards to human health, hindrance to marine activities including fishing, impairment of quality for use of sea water, and reduction of amenities".*

The UN Convention on the Law of the Sea, in 1982, in Article 1, paragraph 1(4), largely followed the GESAMP definition, by describing marine pollution as:

*"...the introduction by man, directly or indirectly, of substances or energy into the marine environment, including estuaries, which results or is likely to result in such deleterious effects as harm to living resources and marine life, hazards to human health, hindrance to marine activities, including fishing and other legitimate uses of the sea, impairment of quality for use of sea water and reduction of amenities;".*

Under Article 1 of the London Dumping Convention, contracting parties pledge to:

*"take all practicable steps to prevent the pollution of the sea by the dumping of waste and other matter that is liable to create hazards to human health, to harm living resources and marine life, to damage amenities or to interfere with other legitimate uses of the sea".*

The GESAMP definition has been used in all internationally agreed legal instruments for the prevention and control of marine pollution. It has been mentioned that the introduction of the same substances into the marine environment that do not cause the above-mentioned negative effects would not be considered pollution. Thus, if hypothetically, it were decided to introduce nutrients into a coastal lagoon to increase fish yield (a documented effect of moderate levels of "pollution" by biodegradable organics or nutrient salts, which has also been

referred to as "enrichment"), this would not be considered as pollution under the GESAMP definition.

### 5.1.1 Waste Disposal at Sea and Environmental Receiving Capacity

Chemical pollution may influence fish production in numerous ways: reduction of stocks by mass mortalities; gradual decline, or changes in composition, of populations or entire ecosystems; increased occurrence of diseases; deterioration of fish-food quality; lowered growth rates. The seas, and land-locked water bodies, receive a significant proportion of pollutant chemicals via the atmosphere, so that effects distant from the source cannot be discounted. Despite this, although such effects need much more rigorous control, there will be great pressure for some use of the marine environment for waste disposal, as a consequence of expected world population growth to some 7 billion people by the beginning of the next century. It would be more practical to attempt to define the levels of pollution that cause no appreciable risk and the areas where such risk is most serious for living resources.

GESAMP (1986) has defined the ability of a component of the marine environment to accommodate a particular level or intensity of human activity as its **environmental capacity,** a concept that is analogous to the benchmarks discussed in section 4.1, above, in relation to fishing intensity. Intrinsic to this concept is the recognition that:

(1) the environment has a finite capacity to accommodate wastes without becoming significantly altered by them;
(2) such a capacity can be quantified.
(3) a certain level of contaminant will not produce an unacceptable impact on the living marine resources;

The impact of the disposal of waste materials at sea, either deliberately or inadvertently, on living marine resources, depends to a significant extent on the location as well as intensity of disposal. Thus, an oil spill in open-ocean waters can be expected to have less serious (though not necessarily negligible) effects than in nearshore Arctic waters. As noted earlier, if disposed of in a responsible manner, moderate levels of waste may in fact enhance the productivity of ecosystems. In many marine environments, diversity and productivity are limited by the relative uniformity of the bottom topography. In cases such as some flat bottom areas, the dumping of materials meeting specified criteria in agreed zones to form artificial reefs might be in contravention of the London Dumping Convention (IMO), but could be considered desirable for the development of coastal resources or to protect sensitive marine habitats from trawling. Thus, there is a need for discussion of exactly what type of dumping, where, and at what intensity, should be considered harmful, and whether existing conventions need modification under certain circumstances in order to promote **sustainable development**.

### 5.1.2 Safety of Aquatic Products

Consumers are becoming increasingly aware of the quality of fish products and of the more stringent regulations being introduced by governments to ensure such quality, which make it more difficult for developing countries to meet minimal standards set out under the FAO-WHO Codex Alimentarius (FAO/WHO, 1993). Discharge into the environment, and subsequent concentration in the food web of such contaminants as heavy metals, PCBs and dioxins, can have an impact on fish-product quality. The problems of contamination of the inland and coastal environments and, consequently, of aquatic products by pathogenic bacteria and viruses contained in water contaminated with sewage, and in uncontrolled

domestic runoff from urban areas, are growing worldwide (Ahmed, 1991). Nutrients from the same sources also encourage blooms of toxic dinoflagellates and red tides that may contaminate fish and shellfish, whether wild or cultured; this type of contamination is paralled in some tropical areas by the increasing prevalence of ciguatera (Pulos, 1986). Other forms of fish toxicity and algal blooms induce fish kills in the tropics (White *et.al.*, 1984). In areas of oil exploitation, catches and fishing gears may have to be discarded because of tainting.

## 5.2 COASTAL CONSTRUCTION

Since human populations tend to prefer living near or at the coast, and coastal human populations are still growing in many countries, construction has increased accordingly, in the form of human residences and hotels, ports, marinas, and the associated infrastructure (sewage treatment plants and rubbish dumps, shops, banks, post offices, hospitals, and so on), as well as industrial installations (see section 5.3, below). Not only does human settlement bring with it the problems of contamination referred to elsewhere in this chapter, but it also threatens the habitat of many species of marine life: fish, turtles, birds, mammals and other organisms that habitually live in the coastal zone, in the sea or on the land nearby. Uncontrolled cutting of mangroves, whether to facilitate coastal construction for shrimp ponds, or to use mangrove wood (e.g. Soepadmo *et al.*, 1984; UNDP/Unesco, 1987), may, in excess, also be examples of environmental degradation that have adverse effects on coastal marine resources.

Perhaps coastal construction itself does not directly affect the fishers (who stand to benefit, at least initially, from the correspondingly increased demand for their catches from the increased human population), but alters the sedimentation pattern and ecological characteristics in the coastal zone. Coastal construction significantly impacts the local marine ecosystems and often forces fishers to change their gear/methods and target species. The traditional practice, in some countries, of landing fish directly on the beach and selling the catch directly to the public (and to the seaside restaurants) may no longer be feasible; fishermen may be forced to go farther to reach the nearest fishing port. This may, for example, force an "improvement" in mechanization of the fishing boats and in the marketing of the fish, but often leads to higher costs for the fishermen and the need to increase fishing effort to meet these higher costs. Thus, coastal construction may improve the capacity of seaside resorts to receive visitors or new residents while making it harder to feed them, as far as the sea-food component of their diet is concerned.

## 5.3 COASTAL INDUSTRY

Industries are established in coastal zones mainly because of the need for a place (the sea) to dump waste, or the use of the sea as a source of cooling water (i.e., to dump heat). Most industries also have to dispose of chemical waste from manufacturing processes (e.g., mercury compounds/fungicides from paper-pulp production), and sometimes physical waste such as sludges (e.g., from the processing of aluminium or titanium oxide ores). Desalination plants, by definition, are sited at the coast; and besides heat, they may discharge hot brines.

Not only can coastal industries degrade the local marine environment where they discharge, but they also occupy the terrestrial environment in their vicinity at the expense of other biologically important critical habitats for marine and coastal species. To the extent that disruption and contamination depress the quality and abundance of the marine fauna, local fisheries are adversely affected by coastal industry; and, in the long term, the sum of all coastal industrial discharges not fully absorbed by the sea has the potential to adversely affect coastal marine fisheries in general. However, it is not always the case that fishes (of

economic, fishery interest) are adversely affected by some forms of chemical pollution. Nevertheless, on the whole, coastal industry (even including industrial-scale fish farming) has the potential to be prejudicial to coastal fishery interests, and needs reconciling with fisheries in the ICAM context.

## 5.4 MARINE MINING

Marine mining includes drilling for oil and gas and dredging of gravel and sand. It may also include the breaking up of coral reefs and the removal of manganese nodules from the ocean floor (Salvat, 1987). Not so well known is the dredging of the sea bed to obtain minerals containing tin, gold, diamonds, ilmenite, rutile, zircon or monazite, for example. The mining of deep-sea manganese nodules (which also contain several other metals, such as cobalt, nickel, iron etc.), will not be a commercial undertaking as long as these metals are found more cheaply on land. When such mining becomes widespread, and especially if some of the industrial processing is done at sea, the consequences for fisheries may become important (discharge of waste rock dust into the sea to create significantly increased turbidity or increased concentrations of elements that are normally rare in sea water but become toxic at higher concentrations, for example). As noted, most sea-bed mining is more costly than land mining, so that this particular intervention is at a relatively early stage of development.

At present, the extraction of oil and gas, for energy and for chemical transformation, is an important marine activity in some regions. Once the exploratory drilling phase is over, and the production platforms are in place, fishing is only likely to be seriously affected if these platforms are closely spaced, so that a substantial area of sea bed is closed to fishing; however, such "platform parks" may provide a "refugium" for fish and an opportunity for sports angling (e.g. Dugas *et al.*, 1979) stock (Reggio, 1987). Platform accidents, leading to discharge of substantial quantities of oil into the sea, are more likely to have adverse effects on other human activities such as tourism than on fishing where more serious adverse long-term effects may stem from toxic waste dumping.

Gravel, sand and fossil coral beds are mined in some areas mainly to provide civil construction materials. In countries where building materials are in short supply or expensive, coastal sea-bed dredging for gravel and sand is often an important marine activity (ICES, 1992a; Campbell, 1993) whose interactions with fisheries are still not well defined. Such extraction adversely affects benthic organisms by destroying habitats and damaging spawning grounds of demersal and other fishes; it also interferes with trawling and other bottom-fishing methods; however, the duration of the effects, once this form of mining has ceased may be relatively short for most smooth bottom habitats. It should be noted that coral reefs have three major ecological functions which are usually seriously compromised by mining: to enclose a coastal lagoon (i.e., create a natural fish pond); to protect the coast (therefore, fish habitat) from coastal waves and storm surges; and to provide a region of attraction for species of fishery interest.

## 5.5 TOURISM AND RECREATION

The recreation of citizens and tourists is a major economic activity in many countries, whether rich or poor. With respect to the coastal zone, wherever clean beaches, sunlight and all the attendant local infrastructure (hotels, places of entertainment, sanitary installations, banks, post offices, shops, etc.) can be found, human beings who can afford to go there, will pay money to do so. In some places, such as along the Mediterranean littoral, a resort's resident population will be multiplied several (3-5) times during the holiday season. (Estimates of several tourists per linear metre of Mediterranean coastline per year have been quoted). This requires significant investment in sanitation services, accommodation (hotels) and other

facilities for the maximum number of residents, even though these facilities will be under-used for perhaps half the year. If the authorities do not provide facilities or services, especially to deal with the increased waste, the coastal sea is relied upon to handle that which cannot be treated. While the sea's capacity to do so may be considerable, it may depend quite heavily on the rate at which the local sea is changed (flushed) by local currents. Untreated waste discharge also leads to increased litter in the sea and on the sea bed, and to higher than usual incidence of potentially dangerous micro-organisms.

The idea of dedicating some parts of the coastline to tourist activity and others to fishing and/or mariculture (i.e., applying the ICAM concept) does not appear to have been widely incorporated into the public policies of most countries, even if there has been some *de facto* geographical separation of human activities, (usually to the disadvantage of fishermen) in the course of development.

## 5.6 COASTAL AQUACULTURE

This subject was taken up in section 2.1.3 under fisheries of the nearshore area. Its impact on traditional capture fisheries is the subject of the present section.

Coastal marine aquaculture may provide a solution to shortage of high-priced species in high demand, which cannot be supplied by fishing. Most such activities are still carried out in coastal lagoons and small, well protected bays. The culture of species of interest (shrimps, sea bream, salmon, for example) is sometimes based on natural stock entrapped in a lagoon or bay and then fed in enclosures until commercial size. Only in certain cases are species raised throughout their whole life cycle (artificial fertilization, culture of the larvae, then reared to commercial size (e.g. Shokita *et.al.*, 1991).

To "force feed" cultured species by the addition of food to the natural environment may, in certain circumstances, lead to abnormal discharge of wastes to the local coastal sea, leading to local eutrophication (Enell and Ackefors, 1991), perhaps causing harmful plankton blooms (e.g. White *et. al.* 1984). GESAMP (1991) has considered ways of reducing the environmental impacts of intensive coastal aquaculture.

Marine aquaculture development may not be viewed favourably by all fishers because of the competition for markets that the cultured species may engender. To avoid future problems as marine aquaculture develops, it is desirable to ensure, where possible, that unemployed or surplus fishers find some role in this sector, as in other coastal sources of employment.

## 5.7 COASTAL SHIPPING

Busy commercial shipping routes are not easily compatible with commercial fishing. Apart from the risk of oil spills, oil tankers, besides being generally very large and not easily manoeuvrable near shore, may wash out their oil tanks (albeit illegally) thus giving rise to a form of oil pollution that may be unfavourable to fishers (degradation of the marine environment, tainting of fish flesh, oiling of fishing gear, especially nets, etc.). Major oil spills may be local catastrophes from the fishery standpoint but, on the whole, the risks of oil and gas transport have perhaps been rather exaggerated with respect to less spectacular forms of pollution discussed in other sections of this report.

## 5.8 POTENTIAL IMPACTS OF AGRICULTURE ON THE MARINE CATCHMENT BASIN

Inappropriate agricultural practices in the hinterland of the coast have the potential to pose a serious problem to coastal fishermen both with respect to pesticide and fertilizer loss.

Pesticides, which may be over-applied, can be washed by rain from the cultivated land surface directly into the sea, or indirectly via rivers debouching into the sea, with potentially adverse affects on the coastal marine fauna and species of fishery interest. There is also a substantial transport of agricultural pesticides by the atmosphere (Goldberg, 1976); they may reach the sea, but over a wide area (regional, if not global) so that although the effects on the coastal sea are not easily quantifiable, distant ecosystems, such as those in the Antarctic , may accumulate detectable levels of industrial chemicals.

The effect of fertilizers washed or discharged via rivers into the sea has been discussed in section 2.1.4; the possible effects on coastal fish stocks, hence on fisheries, are potentially very important, often adversely in the vicinity of point sources, perhaps more positively farther away after dispersion has taken place. Some of the problems of the effects of agricultural fertilizers, with particular reference to nitrogen, have been discussed by Clarholm *et al.* (1988), and also at the 1991 FAO/Netherlands Conference on Agriculture and the Environment (FAO, 1991b).

## 5.9 INTRODUCTION OF EXOTIC SPECIES AND THE BIODIVERSITY ISSUE

The number of species foreign to a particular marine environment that have either been deliberately or accidentally introduced by man has increased considerably, and it is clear that changes in the environment due to human activities may facilitate this process. The establishment of exotic species has often resulted in far-reaching changes to the faunal composition of many of the world's enclosed and semi-enclosed seas, estuaries and coastal marine waters (Li and Moyle, 1981; Carlton, 1989). The effects of such introductions include: immediate ecological impacts at the community level through changes in inter-specific competition and predation; changes in the nature of the environment itself through the influence of certain organisms, and possible genetic degradation of indigenous stocks. FAO has collaborated with ICES in the preparation of a "Codes of practice and manual of procedures for consideration of introductions and transfers of marine and freshwater organisms" (Turner, 1988). The co-introduction of pathogenic organisms has often adversely affected native and introduced species alike, particularly cultured shellfish (Chew, K.K. (1990)).

The conservation of biodiversity and genetic diversity of aquatic organisms (e.g. Norse, 1993; FAO, 1992d, 1993i, Grassle *et al.*, 1990) poses problems at two main levels: firstly, for wild fish stocks, the loss of species and, more especially, local races, through environmental change, overfishing or competition through species introduction. The trend towards developing new, uniform strains adapted to rearing in captivity is increasing the dangers these traits pose to wild populations as a result of the escape of cage-cultured strains, and consequent cross-breeding, e.g. between cultured and wild salmon strains (FAO, 1993i). Such genetic "accidents" could reduce the variability native stocks need to ensure resilience and adaptability in a changing environment (Smith, 1994).

One possible effect of intensive fishing on biodiversity is gear selection for specific fish sizes, depending on the fishing method. Such pressures may also lead to selection for early-maturing or slow-growing individuals, with effects that are expected to be measurable over a limited number of generations (Smith, 1994). This type of effect may be reduced or reversed by alternative fishing strategies.

One special biodiversity problem relates to the influence of man-made canals linking faunistically different regions, and the influence of shipping in facilitating inadvertent transport of exotic species (e.g. Carlton and Geller, 1993). This type of species introduction could be greatly facilitated by a sea-level canal such as the one under consideration to link the Atlantic and Pacific Oceans across the isthmus of Panama (Ambler, 1987). The migration of some 500 Indo-Pacific species into the eastern Mediterranean since the construction of the Suez canal is a specific example of such effects (Por, 1968). This, and their subsequent spread westwards and northwards, was also facilitated by the more saline conditions created by construction of the Aswan Dam and consequent removal of the low-salinity barrier created for Red Sea immigrants by the Nile discharge into the eastern Mediterranean Sea. The dramatic changes in the Black Sea fauna due to the introduction of exotics better adapted to eutrophic conditions than the native fauna is another example (Ivanov and Beverton 1985; Caddy and Griffiths, 1990; GESAMP, 1995).

The **conservation of biodiversity** of aquatic organisms attempts to counteract loss of species and local races, due to harmful practices such as overfishing, habitat destruction and pollution. Although relatively few species extinctions have resulted from overfishing, this is not true for for some populations and races, and other impacts of human activities have been critical through their effects on species habitats. The Convention on International Trade in Exotic Species (CITES) is an important mechanism for protecting commercially valuable species which may be subject to international trade.

In general, the conclusion emerges that, as for terrestrial ecosystems, man's intensive exploitation of all habitats and ecosystems reduces their complexity and favours simple ecosystems and pioneering species of generalists, specialized for rapid growth and reproduction, but not necessarily of commercial value.

## 5.10 POTENTIAL IMPACTS OF GLOBAL CHANGES ON MARINE RESOURCES

Some of the variations in the conditions under which marine ecosystems exist, now, and in the future, are likely to be due to global climate change (e.g. Francis, 1990). Such changes will add to the natural variations all ecosystems have always been subject to (see section 3). Their effects on fisheries and aquaculture are, at best, difficult to forecast, although in the case of 'wild' fisheries, the key role of environmental change on year class strength has been recognized as a significant cause of wide changes in strength of recruited year classes (e.g. Fogarty *et al.*, 1991).

The UNEP-WMO Intergovernmental Panel on Climate Change (IPCC) has assembled the views of the international scientific community on the magnitudes of expected global change related to the climate (IPCC, 1992), and the International Council of Scientific Unions (ICSU) has initiated an International Geosphere-Biosphere Programme (IGBP) to assess the pace of all the major observable terrestrial changes (Williamson, 1992). Regarding the oceans, the IOC has initiated a Global Ocean Observing System (GOOS) (Kullenberg, Andersen and Cole, 1993).

Preparatory studies suggest that carbon dioxide (a "greenhouse" gas) in the atmosphere, is likely to double by 2025-2050 on a "business as usual" basis, leading to a probable increase in the global mean temperature of 1.5°-4.5°C (IPCC, *op. cit.*). This may cause a rise in mean sea level of about 20 cm by 2030, and of about 65 cm by 2100, and to an increase in sea-surface temperature of between 0.2°C and 2.5°C. Bakun (1992) projects some likely effects of such changes on coastal and shelf-sea ecosystems, referring particularly to the likely increase in the temperature differences between the land and the sea

in the coastal zone, which is predicted to amplify upwelling by changing the coastal air-pressure/wind regime.

The global climate changes mentioned above are not expected to have an adverse effect on fish production, as on terrestrial, lacustrine and riverine ecosystems, although particular stocks may be adversely affected and changes in rainfall and river run-off will particularly affect life in semi-enclosed seas and coastal nursery areas. Coastal aquaculture will also be affected. Tropical upwelling zones, which produce large amounts of fish resources, may shift polewards and increase in intensity. The year-to-year variability of the resources they support may increase; however, increased phytoplankton productivity may reduce oxygen levels and lead locally to anoxic situations. Coral reefs may, as in the past, respond to and reflect changes in sea level, but only if these changes occur in a gradual fashion.

## 5.11 INTEGRATED COASTAL AREA MANAGEMENT

The main uses of the coastal area have been mentioned above; they are, beside fishing: waste discharge (pollution); construction of human habitations and related infrastructure; industrial waste discharge and plant cooling; marine mining; tourism and recreation, mariculture and shipping. Sometimes specific areas in the coastal zone may be reserved for military use. As has been suggested in section 5.8, agriculture in the hinterland, although not a "use" of the coastal zone, could have a significant impact environmentally, by way of release of pesticides and fertilizers (an impact which is not always taken into account in cost benefit analysis of agricultural operations).

It is not usual, or perhaps even possible, for all these uses to all co-exist in the same coastal area. Coastal habitation, tourism and recreation, on the one hand, and industry and marine mining, on the other, tend to be mutually exclusive; and all these uses tend to prejudice the pursuit of fishing (perhaps even sport fishing) and marine aquaculture. The application of an ICAM scheme is therefore important, mainly because ecological criteria of choice in terms of space and objectives are unlikely to correspond to political criteria, or criteria expessed in terms of jurisdiction and economics (Clark, 1992): hence the need to search for a working relationship between ICAM and sustainable development.

The objectives of ICAM in a given place, time and socio-economic context are multiple and often conflicting; thus, as for fishery development itself, these objectives must be clear-cut and related to the political, ecological and socio-economic objectives of the responsible government and local authorities in such a way as to maximize the common good. The public perception of this good may not be constant, but it must also be related to the time scale on which human societal development proceeds: that is, decadal. This common good must, in the current climate of social thinking, have sustainable development as its main objective and as defined at the UN Conference on Environment and Development. Burbridge and Burbridge (MS., 1992), Fallon Scura (MS., 1993a) have reviewed the experiences of UNEP, IUCN and WWF in the implementation of integrated coastal management projects.

Regarding fisheries, most of the world fish catch comes from the coastal waters, not only because the positive effects of terrestrial run-off and the physical interaction between the land and the sea have favoured the productivity of coastal waters, but also because here the resources are closest to where a majority of fishermen and consumers live. However, the multiple uses already referred to make the application of fishery management measures in isolation of doubtful efficacy; the appropriate context could properly be referred to as Integrated Coastal Fishery Management (ICFM): implying that other human activities are evluated as suitable or otherwise depending on their impact on fisheries. The common

property idea hitherto predominant in the exploitation of coastal resources has also been largely responsible for the reduction of the resources to levels that no longer sustain the coastal community or even the fishing community itself, in some cases. These two communities (the latter being a subset of the former) have nothing to lose by supporting an effective Integrated Coastal Fisheries Management scheme.

The reduction of user conflict would generally demand the assignation of a value (expressed as some form of rent for use) to a particular area of the coastal zone which would require a restriction on access (either through the economic cost of the rent or through socially established limits), and necessitate zonation (whereby different uses are kept physically separate, so as to avoid adverse impacts on other users and uses, and, perhaps above all, on the environment and the natural resources). Among the measures which fall within coastal zonation, are closed areas or marine parks which ensure that a proportion of the coastal ecosystem is protected from resource exploitation (e.g. Agardy, 1994).

## 6. THE ROLES OF RESEARCH, TECHNOLOGY AND MONITORING

### 6.1 MARINE SCIENTIFIC RESEARCH

The rapid growth in human knowledge of marine ecosystems and their response to human actions over the last few decades cannot disguise the fact that our understanding of these systems is still fragmentary. Various academic disciplines have been pursuing their investigations on components of the marine ecosystem largely independently until very recently, and their efforts still need to be more formally integrated.

To support the proper management of marine resources, fishery research has basically concentrated on commercial fish stocks, and the particular problem of measuring stock abundance, migration (routes and rates), reproduction (life cycle and reproduction strategies), species interactions, bio-economic interactions between fisheries, resource-allocation problems, fishing strategy (distribution of effort by area and season with respect to species of fishery interest), and fleet dynamics.

Sustainable development requires rational harvesting and environmental conservation. A substantial part of fishery development has proved to be non-sustainable partly because of a lack of research on its environmental implications and optimal strategies. Fishery development must therefore be closely linked to research programmes on environmental preservation. To date, the demand for research has tended only to follow stock depeletion and environmental degradation instead of being Precautionary.

The costs of the fishery research needed to support realistic fisheries management systems has been one of the major difficulties facing developing countries. An unbiased resource investigation should place a premium on independent assessment capability. International organizations and the bilateral assistance programmes of disinterested States can, however, advise States with limited capabilities undertaking resource assessments and the needs of small States are particularly relevant to this argument. Such capacity-building is an important element underlying the possibility of achieving sustainable development.

The Study on International Fishery Research (World Bank, 1992) noted that the dominant component of research in the fishery field in developing countries has been, so far, the study of fish biology, and that other disciplines have been relatively neglected. Some forward-looking research priorities in this regard resulted from an April 1994 Expert Consultation on Fisheries Research (FAO, 1994a). Although there have been achievements in the field of stock assessment, capture and post-harvest technology and aquaculture, little

attention has been paid to the users of fishery resources. This, despite the fact that the socio-economic problems confronting users are the main factor leading to the over-exploitation of the resource and, ultimately, to the success or failure of management and development.

The research capabilities of developing countries differ widely. The greatest differences are between regions, mainly reflecting differences in the stages of development, differences in governmental expenditures and research priorities, which, in turn, mainly reflect differences in the economic significance of fisheries in national economies. Nevertheless, there are similar patterns of achievement and shortcomings in the conduct of research and the application of results to fishery management and development. Although many fishery research institutions in developing countries are relatively well developed and can provide basic training, many still rely on foreign universities for advanced training. A further problem is that fishery researchers often still have a low status and income in a given national context, have limited facilities and resources, and sometimes have limited access to outside scientific research information.

The Study on International Fishery Research also stressed the need to improve the application of scientific results to fishery development. There remains an appreciable lack of communication between the producers (scientists) and the users (managers) of scientific results; research programmes often do not address the priority problems confronting fisheries; and, in general, there is a lack of co-ordination between research institutions, fishery administrations and fishery enterprises, and sometimes between fishery research institutions and other relevant scientific research institutions. These shortcomings and difficulties are usually due to the lack of a national fishery development policy elaborated with the participation of all the sectors and interests concerned.

The Study identified four broad areas of research that, if undertaken at the national level, would facilitate the link to international (regional) co-operative research which allows the possibility of sharing expensive equipment and facilities. These four areas are:

(1) Resource conservation and management - covering the management of environmental influences on fishery production, the environmental impact of fishery activities (including effects on human health), the conservation of ecosystems and genetic diversity, and the management and sustainable exploitation of marine resources. In marine capture fisheries, in particular, more research is required on quantitative stock assessment.

(2) Fish productivity - covering the farming of aquatic organisms (aquaculture) and the enhancement of fishery resources; in aquaculture in particular, more research is needed on pond management, feed and water quality.

(3) Fish commodity conversion and utilization - covering all aspects of the conversion of a fishery resource into food: capture; fish handling; processing and marketing; on post-harvest technology, particularly quality control, marketing and consumer protection; so far, very little research has been directed to the development of new fish products of acceptable quality, such as the conversion of the raw material (e.g., small pelagic fishes such as sardine and anchovy) for manufacturing fish meal into economically viable and acceptable products for direct human consumption.

(4) Research is needed on the design and fuel efficiency of fishing vessels

(5) Human linkages - covering the relationship between people and the marine resources they use; in particular, more research is required on the socio-economic aspects of fishing communities, on questions of access to resources, on the incorporation of coastal fisheries into ICAM schemes, and on fishery policy development.

International research could support local research efforts by concentrating on the development of new research theories (such as multi-species models for tropical resource systems) and methodologies applicable to national and regional fishery development; particular attention being paid to the local economic, demographic and ecological factors, including assessment of the implications of global environmental change for fishery resources and their exploitation.

The UN Convention on the Law of the Sea provides a comprehensive framework for international marine research. The desiderata are provided for under the Convention in Articles 239 (facilitating marine scientific research) and 242 (promoting international co-operative research). Although the consent of a coastal State is needed for marine research within its EEZ, under the Convention, a coastal State may only withhold its consent on well founded technical, legal or political grounds admissible to the international community as a whole.

Cooperative research, as well as technical co-operation programmes, must have clearly identified objectives, responsibilities, priorities and deadlines, and be integrated with the relevant national fishery management and development policies and plans. Within a cooperative research programme it may be essential, and certainly will be cost effective, if research were carried out by one research vessel in all the EEZs containing the resource of concern (in order to reduce the time-consuming need for calibration of trawl or acoustic fish-finding equipment if two or more research vessels are required). This type of co-operative arrangement, with scientists from all the States concerned on board, should be facilitated.

Uncertainty is high in the marine environment and the cost of this uncertainty to development is substantial. Research aimed at reducing the uncertainty facing decision-makers means developing the information/data base and tools (e.g., computer simulation models) for risk analysis as an aid to decision-making.

Nevertheless, there is a widespread recognition in developing countries, as well as in development (donor) agencies, of the need to strengthen national research capabilities, hence to increase national self-reliance in this field, particularly since the research must be specific to the local (national) fishery species and ecosystems, and to the local socio-economic and marine policy context.

Although marine resource management should be based on the best scientific evidence available, it also requires governmental and local coastal infrastructure, systems of information diffusion, and consultation between parties concerned. This reflects the fact that, although there is often considerable information available, major changes are still occurring in our perception of the factors that control the abundance of living organisms in the wild that require that the above-mentioned systems be adapted to local conditions.

It needs to be emphasized that, for the proper conservation of resources exploited in common within two or more EEZs, a common research framework, involving exchange of data on catches and fishery survey results, is an essential precondition to sound management, and should be incorporated in the framework of an agreement on the exploitation of the resource under joint study. The negotiation of joint fishing agreements and the designing of appropriate development or management schemes also require an adequate national resource survey capability.

Trained human resources are essential to resource management, which requires, *inter alia*; multi-disciplinary expertise on fishery resource assessment; bio-economic and socio-economic analysis; management techniques; fishing technology, marketing and quality control; resource monitoring; fishery surveillance; and fisheries legislation. Some governments have made considerable efforts to acquire trained human resources and to strengthen their national expertise through training, study tours and scholarships for young scientists and administrators. However, international organizations need to organize regional training courses in these fields, and these courses, as well as other forms of training, should be reviewed regularly to ensure their effectiveness and relevance to needs.

Although financial and manpower resources are limiting factors for many developing countries, this is not an unsurmountable obstacle if international agencies recognize the importance of marine research to the proper management of marine resources.

Adequate funding of national institutes concerned with living marine resources is essential and, for the larger coastal States, should not be neglected in favour of one or a few centres of excellence in the region that have no direct responsibility for management of specific marine resources. The maintenance of a list of experts within a region, and TCDC arrangements, may be more cost effective for developing countries and ensure better application of the available scientific advice to the evolution of the relevant socio-economic activities than using experts exclusively from the developed world.

## 6.2 APPLICATIONS OF NEW TECHNOLOGY

The application of new technology to vessel and gear development has improved safety and the effectiveness of individual fishers, but has often had side effects on other resources captured incidentally by unselective gear. The introduction of new technology has also increased pressures on resources and environment and, especially when associated with industrial-scale operations, may be capital-intensive, energy-inefficient, and more likely to support export markets than to satisfy local requirements for protein. Small-scale fisheries are, however, becoming progressively more effective as a result of the introduction of new technology. They now enjoy a wider sharing of the benefits of marine resource exploitation, and greater, though still limited, employment opportunities in the primary sector, as well as in community-based processing and marketing opportunities in coastal areas. The benefits from marine resources need to be spread more evenly in the chain between harvesters and consumers, however, and the traditional role of women in the processing and marketing must be more widely emphasized.

The resilience of resources and of coastal's communities can be increased by reducing dependence on single resources. Diversification of fishing technologies, with seasonal or part-time revenues from fish processing, aquaculture, tourism and small-scale farming, will all better allow the marine resources to survive in years of low resource abundance than a large work force of full-time fishers. The unthinking application of new technologies in a non-precautionary fashion (see Hey *et al.*, 1991) can be a major source of controversy and conflict with proper resource use, and the equity rights of those already in the fishery.

## 6.3 STOCK MONITORING

Adequate monitoring of the state of stocks and their environment is essential for proper resource management and conservation, but poses specific problems of sampling marine resources whose state, by and large, can only be determined indirectly. Often, an undesirably high degree of uncertainty can only be reduced (but never eliminated) by

significant expenditure on technology-intensive research, of which the systematic, regular use of research vessel, fishery monitoring and statistical systems are the principal components.

The monitoring of commercial catches requires an effective network of national and regional services for the collection of statistics and the establishment of data-bases on landings by species and sizes, on fishing effort by gear type, an up-to-date register of vessels by size and main characteristics, information on the number of registered fishermen, and on the main socio-economic forces operating in the fishery sector.

Direct sampling of marine populations by trawl or acoustic surveys, and oceanographic research, both require a major investment in research vessels and scientific equipment, skilled manpower, and the maintainance of a permanent research team charged with this task. The conversion of their advice into practical management measures requires input from the fishing industry.

In the case of many stocks that migrate or disperse across maritime boundaries, the need for co-operation in management poses a further international dimension of complexity to management, especially if third parties or high-seas fisheries are exploiting the same fish population in adjacent international waters.

Inferences on marine resources may be obtained from the state of the marine environment. This requires interdisciplinary research between oceanographers and fishery workers, physicists, geologists, chemists, meteorologists and many others, with the objective of reducing the uncertainty associated with management of susceptible environments and systems, and of assisting in fishery forecasting. Efforts should also be made, at national and regional levels, to improve the identification, monitoring and protection of critical habitats important to living marine resources. Such geographical information is increasingly being integrated and displayed within Geographical Information (GIS) Systems.

The state of fish stocks may often be inferred from variations in environmental parameters known to be related to fish abundance; the data gathered by the above-mentioned surveys may be usefully supplemented by, for example, remote sensing and oceanographic/meteorological data. The equipment involved is costly and most laboratories in developing coastal countries have insufficient means to monitor adequately the resources of their Exclusive Economic Zones. Countries sharing common problems or interests should ideally, either directly or through an international agency, pool their skilled manpower and research vessels. This approach has already been facilitated by various international programmes, and these multilateral initiatives deserve full support from funding agencies. There is a need to place increased emphasis on ecological modelling in relation to fisheries and their environment, so as to improve prediction of variations in abundance and distribution; this implies greater use of increasingly low-priced computing equipment in the fisheries and oceanographic institutes of developing countries, as well as greater access to specialized software.

# 7. THE INTERNATIONAL FRAMEWORK FOR SUSTAINABLE DEVELOPMENT AND LIVING MARINE RESOURCE USE

## 7.1 THE 1982 CONVENTION ON THE LAW OF THE SEA

The main change in strategy of utilization of marine resources brought about by the UN Convention came from the explicit recognition, under the Convention, that a coastal State has exclusive rights to use the resources within its EEZ. The main provisions on the management of living marine resources within EEZ's are spelled out in Part V (See Annex IV), which also includes provisions relating to straddling stocks, highly migratory species, marine mammals, and anadromous and catadromous species. Extracts are also given in Annex IV of this document, for ready reference, from the most widely quoted provisions of Part VII, which deals with the resources of the high seas and from Part IX on the provisions relating to enclosed or semi-enclosed seas. For a listing of other section headings in the Convention that relate to the marine environment and research, the reader should consult in full UN (1983).

Clearly, the all-embracing nature of the 1982 Convention left many areas to be further developed subsequently. The main objective of the Convention was clearly to provide for a management regime that gave coastal States responsibility for the wellbeing of, and benefits from, the resources lying immediately offshore from their coasts. A complicating issue here that was addressed by the Convention, but not fully developed, related to specifying the management approaches and techniques to use in the case of shared and straddling stocks.

### 7.1.1 Shared stocks

Although marine fish stocks do not recognize maritime boundaries, it was presumed, without being specifically stated, that exploitation of a shared stock will be carried out by two or more States, each within its own EEZ, and the Convention suggests a responsibility to consult in these cases, without entering into technical details on the possible framework for such a consultative body and its likely work programme. How the explicit or implicit provisions of the Convention can be reconciled in practice with the technical factors that ensure resource conservation in the case of shared stocks lying across, or moving between, two or more EEZs, was not fully resolved.

Several examples of the unresolved questions that remained in practice were discussed in Gulland (1980) and Caddy (1982). These are as follows:

(1) An adult resource may be independently managed within two separate jurisdictions without mixing. The planktonic larvae may, however, arrive by oceanic drift from a spawning area in a third jurisdiction, "upstream" from the other two with respect to oceanic current patterns. A variety of human activities close to this spawning area will eventually affect production within all three jurisdictions.

(2) Fish migrating along an archipelago will be fished in turn in each successive jurisdiction, such that the catch in each is probably conditioned by catches in the island EEZs "upstream". (The management implications will not be the same, however, if the species migrates across the archipelago, passing through different EEZs simultaneously (e.g. Mahon, 1987).

(3) A fish stock when aggregating to spawn in a restricted area in EEZ (1) may be highly available to capture as breeding adults, but much less so when widely dispersed during feeding in EEZ (2). The feasibility of overfishing, the needs and costs of management, and the vulnerability to pollution, are all higher within the former jurisdiction. Whether this should affect the relative shares from an overall TAC (Total Allowable Catch) is a question that needs to be resolved in particular cases.

(4) A nursery area for shrimp may lie within a marshland in EEZ(1), but the adults may be mostly fishable in deeper water within EEZ(2). If national fleets are confined to their respective EEZs, the overall yield, consisting in part of juvenile shrimp from EEZ(1), will be much below its potential if all the harvesting could have been carried out in EEZ(2). In the case of refusal of access to EEZ(2) in exchange for banning juvenile fisheries in the zone, coastal State (1) may either: (a) overfish the small inshore shrimp; or (b) cede to pressures to convert the shrimp nursery area to rice culture, for example. The consequent run-off of agricultural chemicals into the estuary may then disastrously affect the stock in both EEZs.

Implicit in the above examples is the idea that coastal States within whose EEZs lie areas of particular vulnerability have special responsibility to avoid overfishing and environmental impacts, and often have unusually favourable fishing opportunities. In some respects, this situation resembles that which led to the drafting and adoption of **Article 66** of the Convention, governing anadromous stocks. The ownership or proper stewardship of critical habitats for the wellbeing of a marine resource has a similar associated management responsibility, but under current international agreements this additional responsibility does not necessarily imply a right to a larger share in the overall yield from the stock.

There appears to be a need to define in practice how the Convention's provisions on shared responsibility for minimizing environmental impacts on resources that are not exclusive to one country, could be applied. The costs of pollution abatement in both cases may not be equally shared, but presumably these costs should be considered when discussing utilization and sharing of the resource.

The question of how to go about setting the total allowable catch and determining surpluses has in fact been treated differently by many countries. A system of allocation of TACs was not specified by the Convention; nor was a specific system of sharing surveillance considered, yet both are essential for successful implementation. One early interpretation was that "there is a cake of some determined size (the "allowable catch") which is then sliced up. The coastal State then takes the slice it wants (determined by its capacity), and the other slices (the surplus) are then theoretically available to be allocated to other States". This interpretation is not fully accepted by all States, since the taking of a surplus, or not, affects the catch rate and hence the profitability of the national fleet, and may also affect national export prospects.

As noted earlier, the probability of stock stability is also likely to be affected with this sharing arrangement, especially if the total harvest, including surplus, was calculated according to the MSY criterion. Thus, many States have followed the criterion set out in **Article 61(2)**, which states that the coastal State "taking into account the best scientific advice available to it, shall ensure through proper conservation and management measures that the maintenance of the living resources in the exclusive economic zone is not endangered by over-exploitation". This does not explicitly require MSY harvesting and, in fact, **Article 61(3)**, states that "Such measures shall also be designed to maintain or restore populations of harvested species at levels which **can** produce the maximum sustainable yield", and specifically qualifies this by citing the need to take into consideration environmental, socio-

economic needs, and the requirements of coastal communities, as well as "special needs" in the case of developing countries.

All of these considerations in fact provide ample scope to justify fishing at levels below that providing MSY and, incidentally, rarely result in à surplus being declared. As was discussed earlier, the biological rationale for these lower levels of resource exploitation appears to be justified by past experience in resource management using the MSY benchmark (see Caddy and Mahon, 1995).

The Convention refers to anadromous and catadromous species **(Articles 66 and 67)** and to the need to preserve rare and fragile ecosystems as well as the resource habitat **(Article 194)**, to avoid land-based pollution **(Article 207)**, and to jointly establish rules, standards, practices and procedures for controlling the release of toxic, harmful or noxious substances, by water or through the atmosphere, from vessels, from sea bed mining and dumping. Specific provisions for estuarine conservation apparently remain to be developed however. Thus, there is currently no international Convention that specifies that the "customary" (seasonal) amounts of freshwater discharge, containing the "customary" levels of nutrient, silt and other substances that need to be maintained if the health of an estuary, its fauna and resources, is to be assured.

In spite of the application of many of the Articles of the Convention, fishing fleets have grown appreciably between 1980 and 1989. Although some fisheries are still operating profitably, on average vessel acquisition and operating costs exceed considerably their income from fishing (FAO 1992e). This over-investment is now seriously threatening the sustainablility of the fishery resources (FAO 1993g).

## 7.2 MAJOR INTERNATIONAL EVENTS SUBSEQUENT TO NEGOTIATION OF THE 1982 CONVENTION

It would be presumptious here to attempt an analysis of the major stepping stones that have occured internationally in the steady movement towards a rational management regime for living marine resources since the 1982 Convention was negotiated. It was felt however that it would be useful to provide readers with some extracts from the relevant International agreements in this field, which could be compared with the broad review of the scientific literature provided in this document. Although the extracts in Annexes IV to VII should not be read in isolation from the full texts, these latter are not readily assembled in one place, and hence it may be useful to have some of the key issues relating to marine resource conservation and management assembled in one place in a readily accessible form.

## 7.3 THE UN CONFERENCE ON ENVIRONMENT AND DEVELOPMENT AND AGENDA 21

This Conference, held in Rio de Janeiro in June 1992, adopted a Programme of Action whose underlying Principles are given in the Rio Declaration on Environment and Development, some extracts of which are given in Annex VI. The application of these principles in a proposed programme of work with technical justifications, is covered by Agenda 21 (UNCED, 1992); a brief description of which is given here, with reference to some key excerpts in Annex VII. The Conference also adopted two Conventions: one on biodiversity and another on global climate change. Both were opened for signature at the Conference.

Regarding fisheries, Chapter 17 of Agenda 21 is the most relevant; its title is **Protection of the Oceans, All Kinds of Seas, Including Enclosed and Semi-Enclosed Seas, and Coastal Areas and the Protection, Rational Use and Development of Their Living Resources** (UNCED *op. cit.*). Some other chapters of Agenda 21 are also of relevance to fisheries, but the reader is referred to UNCED 1992 for details.

Chapter 17 contains seven programmes of action; these are summarized in FAO 1993f. From the point of view of fisheries, the principles established by the Conference most relevant to fisheries are also summarized in the afore-mentioned document). These Programmes of Action and their principal objectives are:

(1) Integrated Management and Sustainable Management of Coastal and Marine Areas, Including Exclusive Economic Zones.

The main objective of this Programme is to promote Integrated Coastal Area Management in areas under the national jurisdiction of coastal States.

(2) Marine Environmental Protection.

The main objective of this Programme is to prevent, reduce and control degradation of the marine environment from sea-based as well as land-based sources so as to maintain and improve the life-support and productive capacities. (In this, it follows very closely the UN Convention on the Law of the Sea, and takes into account the coastal States' policies, priorities and resources).

(3) Sustainable Use and Conservation of Marine Living Resources of the High Seas.

The objective of this Programme is to pursue the commitment of States to conserve and to use high-seas resources on a sustainable basis, and to assist developing countries in this endeavour. However, owing to the failure, in Rio, to reach a consensus on some of the issues of conservation and management of high seas resources, States were called on to, **inter alia**, convene an inter-governmental conference on straddling stocks and highly migratory species, under UN auspices.

(4) Sustainable Use and Conservation of Marine Living Resources under National Jurisdiction.

The main objectives of this Programme are the restoration of resources to levels that would allow the maximum sustainable yield to be taken; protection of endangered species; and the taking into account of the interests of local communities and small-scale fisheries.

(5) Addressing Critical Uncertainties for the Management of the Marine Environment and Climate Change.

The main objectives of this Programme are: to improve the capacity of coastal States to deal with the consequences of climate change; to improve capacity to forecast conditions and effects, in coastal areas, in respect of changes in water temperature, sea level, river discharge, atmospheric ozone concentration etc.; and to promote relevant research.

(6) Strengthening International, Including Regional, Cooperation and Coordination.

The main objectives of this Programme are: to better integrate sectorial activities; to promote effective information exchange and inter-governmental review of environment and development issues; and to promote effective operation of co-ordination mechanisms for the relevant components of the UN system and of international development bodies.

(7) Sustainable Development of Small Islands.

Because of the very high ratio of EEZ to land area, small islands are exceptionally dependent on their marine resources, hence on their **sustainable development**; therefore, the primary objective of this Programme is to assist small island States to develop their marine resources on such a basis, with particular attention also to the related socio-economic development and the maintenance of biological diversity.

Many of the needs identified by the Rio Conference, and embodied in Agenda 21 with respect to fisheries, were foreseen in the FAO World Conference on Fishery Management and Development (FAO, 1984, 1986b). The FAO Department of Fisheries has, in effect, already been addressing many of the relevant recommendations of UNCED; moreover, most of these needs have been discussed in the present document.

The many suggestions for FAO action given in FAO (1993g) were also approved by the FAO Committee on Fisheries at its twentieth session (Rome, March 1993). These and other suggestions for action have been laid out in sections 2.1.5, 2.2.5, 2.3.4, 2.4.4, 2.5.3, 2.6.1, on the specific ecological provinces addressed in the present document, and 7.6, on the general questions of the sustainable development of fisheries.

The texts of the third and fourth of the above Programmes are given in Annex VII, largely to illustrate the style and practical approach adopted in Agenda 21.

## 7.4 THE ROLE OF INTERNATIONAL ORGANIZATIONS

Fisheries have been regulated in various ways for centuries and, as fleets increased in mobility, international collaboration became necessary to try to ensure the sustainability of the yield from shared stocks. The fact that many resources and some areas fall outside EEZs, and also outside the geographic area and terms of reference of regional Commissions, is a serious cause for concern.

A number of international organizations are involved with human activities in the oceanic environment, and the following specific programmes of the United Nations, its specialized agencies, and other key players are mentioned in more detail in Annex III, and their acronyms given in Annex II. One of the roles of FAO with respect to marine resource use has been to support the operation of a number of fisheries commissions, especially in developing areas of the world. Brief descriptions of the main FAO Fisheries Commissions are given in Annex III under the FAO heading. One of the roles of an international Organization is to provide a focal point for international agreement on issues of concern to its member countries. Such a role was fulfilled by FAO in assisting with organization of the International Conference for Responsible Fisheries in Cancún, Mexico, 6-9 May 1992. This resulted in the Cancún Declaration, and initiated the concept of "responsible fishing" now being pursued by member countries of FAO in discussions on a Code of Conduct for Responsible Fisheries. The Cancún Declaration took into account not only the provisions of the 1982 Convention and the 1984 FAO World Conference on Fisheries Management and Development, but also the deliberations of UNCED . Extracts from the Cancun Declaration are given in Annex V.

## 7.5 THE EFFECTIVENESS OF FISHERY COMMISSIONS AND CONVENTIONS

The management of some key resources of the world's oceans are covered by the deliberations of fishery management bodies, whose role is particularly important when these are shared or straddling stocks. Some resources managed by such commissions, as for tuna or whales, may be harvested on the high seas and pose major problems of monitoring and control. The UN General Assembly has recently expressed its concern over certain high-seas fishery issues, and it is clear that given the regional and species-specific nature of most fishery commissions, they inevitably lack a certain cohesion in dealing with inter-ocean and intra-ocean problems.

The mechanisms proposed under the UN Convention on the Law of the Sea for the management of living marine resources assign a key role to regional fishery commissions, particularly in the case of stocks straddling, or moving between, two or more EEZs, or straddling, or moving between, EEZs and international waters. To what extent can fishery commissions, as currently constituted (see section 7.5), fulfil this mandate?

The first consideration relates to their coverage. As already explained, there are commissions whose principal mandate is restricted to one or a limited group of species. These species-specific commissions play a key role with respect to conservation of what are often apical or keystone predators, particularly vulnerable to exploitation by man.

Savini (1991) and Marashi (1993) have provided more detail on world fishery commissions, but in a brief summary, we will consider first those commissions that deal with marine resources generally, usually in a particular ocean region. The present world coverage by existing commissions of this more general type is relatively complete; the major exceptions being FAO statistical areas 18 (The Arctic), the western parts of area 61 (The Northwest Pacific), area 77 (The East Central Pacific), area 41 (The Southwest Atlantic: covered by CARPAS which has, however, been inactive for many years), and area 47 (formerly covered by ICSEAF which has since been disbanded). Other conspicuous gaps are: area 71 (The South China Sea which is, however, considered by a committee of the IPFC, a body with unspecified geographical boundaries); the southern part of area 81 (Southwest Pacific), and the Black Sea (once partly covered by the now inactive Black Sea Fishery Commission, and by GFCM; both bodies have incomplete membership of the coastal States). New commissions or consultative bodies (e.g., PICES; created for the North Pacific on the model of ICES) have been proposed or newly created, and extensions or redefinitions of the roles of existing bodies (e.g., the Indo-Pacific Fishery Commission) continue to be discussed. Some multinational groupings, such as the EU for the North Sea and adjacent areas, the Forum Fishery Agency for the central Pacific, SEAFDEC for south east Asia, CARICOM (The Caribbean Community) and OECS, (The Organization of Eastern Caribbean States) effectively carry out some of the functions of a fishery commission for the area enclosed by the combined EEZs of their Member States.

Even with the qualifications mentioned so far, the effectiveness of many existing fishery commissions is often much less than desirable for the following reasons:

(1) Some of these bodies are either relatively inactive; others are advisory bodies without legislative or executive powers to manage resources (e.g., ICES) or have not been able to use their regulatory powers for the management of transboundary stocks. Some (e.g. INPFC and NAFO) have regulatory competence within only a restricted part of the areas included in their convention, and only manage a fraction of the species within the area of jurisdiction.

(2) Some commissions concerned primarily with coastal and shelf resources pay little attention to the resources of offshore waters nominally falling within their terms of reference and competence.

(3) Fishery commissions usually function on the basis of consensus among their contracting parties or member countries, have poor information and no control over fishing by non-members, nor an independent capability to detect or punish infringements or misreporting by Member States. The required consensus for different management measures is often hard to achieve. Although few have binding authority in basic conservation matters, several have been successful in applying economic pressure to achieve some conservation objectives.

(4) Many commissions lack sufficient financial support, sometimes because they have not been able to extract prompt payment of dues by all their Member States. Consequently, they lack properly constituted and staffed Secretariats and, largely as a consequence of this, and the often low level of commitment of their Member States, they may lack the basic data required to properly identify conservation needs.

(5) Vessels from flag States that are not members of a commission or party to an agreement are nevertheless under the obligation to comply with measures that Member States have to take on the basis of their general duties in the conservation of high-seas resources under Articles 117-119 of the UN Convention on the Law of the Sea.

Clearly there is a need to continually review and update coverage of areas and species by management bodies, to review their powers and funding and, if feasible, to correct for some of these anomalies and for the Commissions to define future areas for collaborative action by them, with the main aim of avoiding duplication of effort, sharing of fishery statistics and information, and transferring expertise and technology.

The **sustainable development** of the marine environment today calls for striking a balance, at the international, regional, national and local levels, between the needs of the various sectors sharing the marine environment. To be sustainable, however, there is a requirement that areas of priority be assigned which reflect the fact that some activities are impacted in a non-sustainable way by others. The International Organizations mentioned in Annex III have set up a number of joint bodies to ensure this in different fields, such as in the field of marine pollution covered by GESAMP (see References).

Conventions have already been developed for several semi-enclosed seas; these are principally concerned with the protection of the marine environment. The main ones are:

(1) The Mediterranean: The Barcelona Convention for the Protection of the Mediterranean Sea against Pollution, 1976, (with protocols on oil and harmful substances, dumping, land-based pollution and specially protected areas).

(2) The Persian Gulf: The Kuwait Regional Convention for Co-operation on the Protection of the Marine Environment from Pollution, 1978, (with protocols concerning co-operation in combatting oil spills and other harmful substances).

(3) The Red Sea and Gulf of Aden: The Jeddah Convention for the Conservation of the Red Sea and Gulf of Aden Environment, 1982, with a similar protocol to the foregoing.

(4) The Caribbean region: The Cartagena Convention for the Protection and Development of the Marine Environment of the Wider Caribbean Region, also with a protocol for combatting oil spills.

(5) The Baltic Sea: The Helsinki Convention for the Protection of the Marine Environment of the Baltic Sea Area, 1974.

(6) The North Sea: The Oslo Convention for the Prevention of Marine Pollution by Dumping, 1972 (also covers the northeast Atlantic) and the Bonn Agreement for Co-operation in Dealing with Pollution of the North Sea by Oil, 1969 and 1983.

It is worth noting that most of the other semi-enclosed seas lack specific internationally registered protocols for protection of the marine environment and resources, although bilateral environmental and fishing agreements may exist in some cases, such as that between Venezuela and Trinidad and Tobago on access to Gulf of Paria fisheries, and between Argentina and Uruguay for hake fisheries in the common fishing zone off the River Plate.

The Regional Seas Programme of UNEP is designed particularly to address the environmental problems of semi-enclosed seas, and needs to be extended to other semi-enclosed seas. However, only two of the eight UNEP Regional Seas Conventions have currently been supplemented by protocols on the prevention and control of pollution from land based sources.

With respect to fisheries, a significant proportion of human experience and skilled manpower in the field of marine resource and environmental management is located around these "core" seas. For example, the North and the Irish Seas, the Baltic, the Sea of Japan, and the Mediterranean and Black Seas, are all subjects of investigation by teams of experienced scientists. As noted by Smith and Vallega (1990), these human resources will need to transmit their skills to the equivalent bodies that should be set up for other enclosed and semi-enclosed seas.

Major deficiences in co-ordination of actions exist between bodies concerned with environmental protection and those concerned with fisheries; statutory bodies charged with combining environmental and resource protection have not yet been set up, and this continued division is also reflected in the relatively little cross-fertilization between marine resources research and marine environmental studies.

More integration between organizations concerned with environmental conservation and the appropriate regional fishery commission would reinforce the efforts being made to reduce human impacts on the environment so as to ensure a healthy resource base.

Some specific suggestions for action have been made earlier in relation to specific ecological provinces (section 2). In the present section, common elements that are of general concern in relation to **sustainable development** of living marine resources are brought together here below. As in section 2, the action is first specified (**boldface**) with complementary text in parenthesis (lightface).

### 7.5.1 Proposed actions

7.5.1.1 Increasing National Capacity

(i) **Effective overall governmental control over the marine resources under national jurisdiction is a precursor to proper management.** (Government should take the lead in setting national standards, supporting the research needed for resource assessment, encouraging international collaboration, and promoting education in marine affairs. At the same time, the delegation of some rights and responsibilities, under specified conditions, to communities, local organizations or even individuals appears to be the key to sustainable development of the marine environment).

(ii) **Compilation of reliable and timely statistics is needed on all aspects of marine resource utilization, and the incorporation of statistical systems into the management and control provisions at national and local levels.** (The provision of accurate information on removals from the marine environment should be a precondition of access to exploitation of marine resources).

(iii) **The initiation by governments of fishery management measures should be effected before, rather than after, overfishing becomes evident.** (Marine fisheries are not self-regulating, and proper management of marine resources is not ensured by the existence of a market for marine products. Supply and demand are now largely determined globally, and local safeguards are required to ensure continuity of supply of marine food products to markets).

(iv) **Pre-emptive regulation, with regular review of the resource data, started early in the development stage of a fishery, should take into account experience with similar fisheries elsewhere, since such regulation cannot await the availability of complete data on the resource.** (The consequence of an over-cautious precautionary evaluation is a possible loss in revenue over a few years, whereas an over-optimistic evaluation, or no action at all, may lead to resource collapse in the long run and for a long period, if not permanently, with the consequent need for expensive and socially unpopular restoration measures).

(v) **Encouragement of free trade and free-market economies are essential for development, but need parallel governmental safeguards to protect natural resources.** (Without control of access to the resource, market demand leads to effort increases beyond optimum levels for economic resource use, and compromises the biological stability of the associated biological community).

(vi) **The proportion of fish directly available for human food should be increased by avoiding wastage and improved techniques of capture, handling and transportation.** (To the extent possible, fish for human food should take priority over its other uses; for example, substitutes should be found where possible, for the use of fish protein as animal feed).

(vii) **The understanding of the importance of fish for nutrition needs, and the establishment of quality assurance and fish inspection systems are both required, as well as systems for measuring contamination of marine products as a result of pollution.**

(viii) **Government support is needed for the development of institutions to undertake relevant research, and provide the information needed for sustainable development and management of living marine resources.**

(ix) **A wider diffusion of suitable technology required to improve understanding of the oceans and the marine environment, is a priority, particularly for institutes in developing countries.** (This technology includes remote-sensing systems, computer modelling, data bases and data and image analysis techniques. It also requires sharing, on a regional basis, expensive facilities such as research vessels and remote-sensing systems. Wide diffusion of skills can be facilitated by training, networking, increased exchange of personnel between institutes in developing and developed countries, and by sea-going experience on research vessels. All of these mechanisms should be fostered and promoted by international aid agencies).

(x) **Geographical Information Systems for the quantification and appraisal of living marine resources and fisheries, their environment and the coastal communities involved in their sustainable use are required, not only for exclusively national resources, but also for shared resources and for high-seas resources, as an aid to decision-making.**

(xi) **Increased application of new technological developments, such as remote sensing, computer modelling and GIS, to all marine ecosystems and fish stocks under exploitation, could improve forecasting of the effects of natural or man-induced environmental change.**

(xii) **Basic, applied and management-oriented research should be promoted, with particular emphasis on the marine resources and environment.**

(xiii) **Promotion of information diffusion on the need for conservation of the marine environment, with the involvement of all groups concerned, at all levels is required, as well as the development of legislation to protect renewable resources for the use of present and future generations.**

(xiv) **Marine environmental issues need to be incorporated into school and university curricula, and public awareness of these issues promoted, particularly in coastal communities.**

7.5.1.2 Straddling Stocks

(i) **The harmonization of policies and legislation by States exploiting resources in common should lead, where possible, to common rules, standards and procedures to prevent pollution.** (Legislation for environmental and resource management could, for example, have built-in clauses covering the financing of these actions and the underlying research they require).

(ii) **A common or at least compatible framework for the regulation of stocks exploited in common is required, including vessel licensing and marking, common log books for compulsory reporting of catches, common mesh sizes and other gear specifications, and common procedures for control and surveillance should help to achieve cost-effectiveness, and encourage mutual confidence between the parties concerned.**

7.5.1.3 International Organizations

(i) **A greater effort is needed by all international organizations concerned with marine affairs to promote effective co-operation between themselves and between their Member Nations in all matters relating to sustainable development of high-seas areas, their resources and environments.**

(ii) **Mechanisms should be improved for co-ordination and information flow between concerned organizations and government departments, and strategic planning incorporated into decision-making relative to renewable resource use.**

(iii) **Training in marine affairs at an advanced, interdisciplinary level will be needed, with particular emphasis on the integration of environmental and resource management at the ecosystem level.** (The financial advantages accruing to national technical experts should ideally be commensurate with the costs of training and alternative employment opportunities in the private sector).

(iv) **The building of national competence should be pursued by the provision of training material, specialized software and advisory services, and supporting regional centres of excellence, particularly for small island countries with limited human resources and expertise.**

(v) **Guidelines should be developed for the application of the UN Convention on the Law of the Sea to the monitoring and protection of sensitive or special environments of high importance to marine production.**

(vi) **The development of national legislation should be assisted in areas embodied in relevant international conventions such as control of the transfer of live marine species and the promotion of responsible fishing.**

(vii) **Regional approaches, such as co-operative research and workshops, to the definition of shared or straddling stocks and the measurement of their genetic diversity, should be promoted.**

## 8. REFERENCES

Abe, K. and S. Pekpiroon (1991). Fluxes and accumulation of phosphore in the east coast of the Gulf of Thailand. *Thai Mar.Fish.Res.Bull.*(2):59-68

Ackefors, H. and M. Enell (1990). Discharge of nutrients from Swedish fish farming to adjacent sea areas. *Ambio* 19(1):28-35

Ackefors, H., V. Hilge and O. Linden (1990). Contaminants in fish and shellfish products. Aquaculture Europe 1989. Business joins science. N. De Pauw and R. Billard (eds.). European Aquaculture Society. Special publication (12):305-44

Agardy, M.T. (1994). Advances in marine conservation: the role of marine protected areas. TREE 9(7):267-70

Ahmed, F.E. (ed) (1991). Seafood safety. National Academy Press, Washington DC USA.

Alcala, A.C., E.D. Gomez and B. Salvat (1987). Dynamiting coral reefs for fish: A resource-destructive fishing method. Impacts des activités humaines sur les récifs coralliens: connaissances et recommandations, pp. 51-60.

Alexander, L.M. (1973). Special circumstances: semi-enclosed seas. *In*: Gamble, J.K. and G. Pontercorvo (eds.). Law of the sea: Emerging regime of the oceans. Bollinger, Cambridge, Mass.

Allen, K.R. (1971). The relationship between production and biomass. *J.Fish.Res.Bd.Can.*, 28 (10):1573-81.

Alverson, D.L., M.H. Freeberg, S.A. Murawski and J.G. Pope. (1994). A global assessment of fisheries bycatch and discards. FAO *Fish.Tech.Pap.*(339):233 p. (+floppy disc).

Ambio (199O). Status of the Baltic Sea: a sea in transition. *Special Report* (7):24 p.

Ambler, H.M., Jr. (1987). The future of the Panama canal. 94-98p. *In*: Caribbean Marine Science. Oceanus (30):4, winter 1987/1988.

Anon. (1985). Selected papers submitted to the International Conference on Ciguatera, San Juan (Puerto Rico), 23-25 April 1985. *In:* Marine Fisheries Review (USA), 48(4):93 p.

Anon. (1986). First periodic assessment of the state of the marine environment of the Baltic Sea area, 1980-1985: general conclusions. *Baltic Sea environmental proceedings*: (17)A: Helsinki Commission.

Anon. (1987). Our common future. World Commission on Environment and Development. Oxford University Press, 383p

Anon. (1990). Second periodic assessment of the state of the marine environment of the Baltic Sea, 1984-1988: general conclusions. *Baltic Sea Environmental Proceedings*: (35)A:32 p.

Anon. (1995). A North Sea view: Birdlife International's recommendations to the 4th International Conference on the Protection of the North Sea. Birdlife International, Welbrook Court, Girton Road, Cambridge CB3 ONA, U.K. (Mimeo):51p

Andersen, K.P. and E. Ursin (1977). A multispecies extension to the Beverton and Holt theory of fishing, with accounts of phosphorus circulation and primary production - *Meddr.Danm.Fisk.*-og Havunders., N.S. (7):319-435

Andreae, M.O. (1989). Flux of volatile sulphur species across the air/sea interface. 70-6 p. *In*: The ocean as a source and sink for atmospheric constituents. Final Report of SCOR Working Group 72. *Unesco Technical Papers in Marine Science:* 56:102. UNESCO, Paris, France.

Apollonio, S. (1994). The use of ecosystem characteristics in fisheries management. *Rev.Fish.Sci.*2(2):157-80

Avedikova, T.M. *et al.* (1982). On the stocks of principal commercial species of fish from the Azov sea. *In:* Collected papers on the biological productivity in the Azov and Caspian seas. VNIRO, Moscow, CIS. 152 p.

Avery, W.H. (1994). Renewable energy from the ocean. A guide to OTEC. Oxford University Press, New York, 446 p.

Baden, S.P., L.O.Loo, L. Pihl, and R. Rosenberg (1990). Effects of eutrophication on benthic communities including fish: Swedish west coast. *Ambio* (19):113-22

Bakun, A. (1990). Global climate change and intensification of coastal ocean upwelling. *Science* (247):198-201

Bakun, A. (1992). Mechanisms of physical-biological interaction in coastal marine ecosystems in relation to projected trends of global change. Paper submitted to the Bremen Marine Training Centre's International Workshop on marine environmental protection and coastal living resources monitoring: training and implementation. 29 September - 3 October 1992, Bremerhaven, Germany. 10 p.

Bakun, A. (1993). The California current, Benguela current, and Southwestern Atlantic shelf ecosystems: a comparative approach to identifying factors regulating biomass yields. 199-224. *In*: Large marine ecosystems - stress, mitigation, and sustainability. K. Sherman, L.M. Alexander and B. Gold (eds). American Association for the Advancement of Science.

Bakun, A. (in press). Patterns in the Ocean: Ocean Processes and Marine Population Dynamics. A book published jointly by Centro de Investigaciones Biológicas de Baja California Sur, La Paz, Mexico and University of California Sea Grant, San Diego, USA.

Bakun, A. and R.H. Parrish (1980). Environmental inputs to fishery population models for eastern boundary current regions. Intergovernmental Oceanographic Commission, UNESCO, Paris, *IOC Workshop Rep.* 28:67-104

Barg, U.C. (1992). Guidelines for the promotion of environmental management of coastal aquaculture development. FAO *Fish.Tech.Pap.*(328):122 p.

Barg, U.C. and U.N. Wijkstrom (1994). Environmental management options for coastal fisheries and aquaculture. *Marine Policy* 18(2):127-37

Beddington, J.R. (1978). On the risks associated with different harvesting strategies. *Rep.Int.Whal.Comm.* (28) (SC/29/6):165-67

Beddington, J.R. and R.M. May (1977). Harvesting natural populations in a randomly fluctuating environment. *Science* (197) (July 1977):463-5

Berkes, F. (1985). Fishermen and "the tragedy of the commons". *Environmental conservation* 12(3):199-206

Berkes, F., C. Folke and M. Gadgil (1993). Traditional ecological knowledge, biodiversity, resilience and sustainability. *Beijer Discussion Paper Series* (31):32 p. Swedish Academy of Sciences.

Beverton, R.J.H. and Holt, S.J. (1957). On the dynamics of exploited fish populations. Her Majesty's Stationery Office, London, UK. 533 p.

Bidigare, R.R. (1989). Potential effects of UV-B radiation on marine organisms of the Southern Ocean: Distributions of phytoplankton and krill during austral spring. *Photochem.Photobiol.*(50):4 pp.

Birkeland, C. (1982). Terrestrial runoff as a cause of outbreaks of *Acanthaster planci* (Echinodermata: *Asteroidea*). *Mar.Biol.*(69):175-85.

Boddeke, R. and P. Hagel (1991). Eutrophication of the North Sea continental zone, a blessing in disguise. ICES Document C.M. 1991/E:(7):18 p. (Mimeo).

Boesch, D.F. and R.E. Turner (1984). Dependence of fishery species on salt marshes: the role of food and refuge. *Estuaries*, 7(4A):460-68

Brander, K.M. and D.B. Bennett (1989). Norway lobsters in the Irish Sea: modelling one component of a multispecies resource, 183-204. *In*: Caddy J.F. (ed.). Marine invertebrate fisheries. John Wiley and Sons, Inc. 752 p.

Brockmann, U., G. Billen and W.W.C. Gieskes (1988). North Sea nutrients and eutrophication, 348-89 p. *In*: W. Salomons, B.L. Bayne, E.K. Duursma and U. Forster (eds.). Pollution of the North Sea: an assessment. Springer-Verlag, Berlin.

Brown, L.B., H. Kane and D.M. Roodman (1984). Vital Signs 1994. The trends that are shaping our future. W.H. Norton & Co. 160 p.

Burbridge, P.R. and V. Burbridge (1992). Review of the experiences with integrated coastal management projects by UNEP, IUCN and WWF. (manuscript, 68 p.)

Buxton, R. and D. Robertson (1989). A Report on the International Fisheries Energy Optimization Workshop; 28-30 August 1989, U.B.C., Vancouver, B.C. General Education Series (10):21 p. Fisheries and Oceans, Canada.

Caddy, J.F. (1979). Long-term trends and evidence for production cycles in the Bay of Fundy scallop fishery. *Rapp. et p.-v.Réun.Cons.Int.Explor.Mer.*(175):97-108

Caddy, J.F. (1982). Some considerations relevant to the definition of shared stocks and their allocation between adjacent economic zones. FAO *Fish.Circ.*(749):44 p.

Caddy, J.F. (1983). Advances in assesment of world cephalopod resources. FAO *Fish.Tech.Pap.*(231):452 p.

Caddy, J.F. (1984). An alternative to equilibrium theory for management of fisheries 63-75p. *In* FAO *Fish.Rep.*(289) Suppl.2:214 p.

Caddy, J.F. (1990). A contrast between recent fishery trends and evidence for nutrient enrichment in two large marine ecosystems: the Mediterranean and the Black Sea. Presented at the conference on the large marine ecosystem (LME), concept and its application to regional marine resource management. Monaco, 1-6 October 1990.

Caddy, J.F. (1993a). Towards a comparative evaluation of human impacts on fishery ecosystems of enclosed and semi-enclosed seas. *Rev.Fish.Sci.*, 1(1): 57-95

Caddy, J.F. (1993b). The age structure of fishing fleets and its relevance for reconstructing past fishery trends and forecasting. Lowell Wakefield Fishery Symposium on "Management Strategies for Exploited Fish Populations"; Anchorage, Alaska, 21-24 October 1992.

Caddy, J.F. (1993c). Some future perspectives for assessment and management of Mediterranean fisheries. *Scientia Marina*, 57(2-3):121-30

Caddy, J.F. and A. Bakun. (1994). A tentative classification of coastal marine ecosystems based on dominant processes of nutrient supply. *Ocean and Coastal Management*, (23):201-11

Caddy, J.F. and A. Bakun (1995). Marine catchment basins and anthropogenic effects on coastal fishery ecosystems. Proceedings of the 2nd International Conference on Environmental Management of Enclosed Coastal Seas. Baltimore, Maryland, USA, 10-13 November 1993.

Caddy, J.F. and J. Csirke (1983). Approximations to sustainable yield for exploited and unexploited stocks. *Oceanogr.Trop.* 18(1):3-15

Caddy, J.F. and G.D. Sharp. (1986). An ecological framework for marine fishery investigations. FAO *Fish.Tech.Pap.*(283):152 p.

Caddy, J.F. and R.C. Griffiths. (1990). A perspective on recent fishery-related events in the Black Sea. *In:* Recent trends in the fisheries and environment in the general fisheries for the Mediterranean (GFCM) area. General Fisheries Council for the Mediterranean Studies and Reviews, (63):43-71. FAO, Rome, Italy.

Caddy, J.F. and J.A. Gulland. (1983). Historical patterns of fish stocks. *Mar.Pol.*(7):267-78.

Caddy, J.F. and R. Mahon (1995). Reference points for fishery management. FAO *Fish.Tech.Pap.*(347).

Calzada, N., C.H. Lockyer and A. Aguilar (1994). Age and sex composition of the striped dolphin die-off in the Northern Mediterranean. *Mar.Mamm.Sci.* (10)3:299-310.

Campbell, J.A. (1993). Guidelines for assessing marine aggregate extraction. Ministry of Agriculture, Fisheries and Food, Directorate of Fisheries Research, Lowestoft. Laboratory Leaflet (73):12 p.

Carlton, J.T. (1989). Man's role in changing the face of the ocean: biological invasions and implications for conservation of near-shore environments. Conservation Biology 3(3):265-71.

Carlton, J.T. and J.B. Geller (1993). Ecological roulette: the global transport of non-indigenous marine organisms. *Science*, (261):78-82

CCAMLRR (1988). Addendum to the repport of the seventh meeting of the Commission (Doc. CCAMLR-VII):18 p.

CCAMLRR (1993a). Basic documents. 6th Edition, 1-24 p. (available from: CCAMLR, 25 Old Wharf, Hobart, Tasmania 7000 Australia).

CCAMLRR (1993b). CCAMLR's approach to ecosystem management, *In*: Report of the twelfth meeting of the commission: Hobart, Australia, 25 October - 5 November 1993. Annex (8):129-33. Commission for the Conservation of Antarctic Marine Living Resources, Hobart, Tasmania, 133 p.

Chew, K.K. (1990). Global bivalve shellfish introductions. *World Aquaculture*, 21(3):9-22.

Chou, L.M., H.W. Chua, P.E. Lim, J.N. Paw, G.T. Silvestre, M.J. Valencia, A.T. White and P.K. Wong, editors, (1991). Towards an integrated management of tropical coastal resources. ICLARM Conference Proceedings 22, 455 p. National University of Singapore; National Science and Technology Board, Singapore; and International Center for Living Aquatic Resources Management, Manila, Philippines.

Christie, W.J. (1993). Developing the concept of sustainable fisheries. *J.Aquat.Ecosystem Health* (2):99-109.

Christy, F.T., Jr. (1982). Territorial use rights in marine fisheries: definitions and conditions. FAO *Fish.Tech.Pap.*(227):10 p.

Chua, T.E. (1992). Coastal aquaculture development and the environment. The role of coastal area management. *Mar.Pollut.Bull.*, 25:98-103.

Chua, T.E., J.N. Paw and F.Y. Guarin (1989). The environmental impact of aquaculture and the effects of pollution on coastal aquaculture development in Southeast Asia. *Mar.Pollut.Bull.*, 20(7):335-43.

Chua, T.E. (1993). Environmental management of coastal aquaculture practices and their development, pp. 192-212. *In*: R.S.V. Pullin, H. Rosenthal and J.L. Maclean (eds.). Environment and Aquaculture in Developing Countries. *ICLARM Conf.Proc.*(31):359 p.

Chua, T.E. and L. Fallon Scura (eds.) (1992). Integrative framework and methods for coastal area management. ICLARM *Conf.Proc.*(37):169 p.

Clarholm, M. *et al.* (1988). Does agriculture kill fish? Possible ways to decrease nitrogen reaching from land to water. *Ecol.Bull.*(39):139-40.

Clark, C.W. (1976). Mathematical bioeconomics: the optimal management of renewable resources. Wiley-Interscience, New York, USA. 352 p.

Clark, J.R. (1992). Integrated management of coastal zones. FAO *Fish.Tech.Pap.*(327):167 p.

COFI (1991). Environment and sustainability in fisheries. Committee on Fisheries, FAO, *Doc.* COFI/91/3, 23 p. (Mimeo).

Christensen, V. and D. Pauly (1993). Trophic models of aquatic ecosystems. *ICLARM Conf.Proc.*(26):390 p.

Constanza, R. (1992). Towards an operational definition of ecosystem health. *In*: R. Constanza, B.G. Norton and B.D. Haskell (eds.). Ecosystem Health: New Goals for Environmental Management. Island Press, Washington DC, USA.

Crean, K. and D. Symes (1994). The discards problems: towards a European solution. *Mar.Pol.*18(5):422-34.

Cushing, D.H. (1982). Climate and fisheries. Academic Press, 373 p.

Cushing, D.H. (1990). Recent studies on long-term changes in the sea. Freshwater Biology (23):71-84.

Daan, N. (1989). The ecological setting of North Sea fisheries. *Dana* (8):17-31.

DANA (1989). Special issue on the future of the North Sea. (8):129 p.

Dawson, C.L. (1980). Glossary of terms and concepts used in fishery management. ACMRR Working Party on the scientific basis of determining management measures. *FAO Fish.Rep.* (236):115-130

Deegan, L.A. and J.W. Day Jr. (1987). Coastal fishery habitat requirements: pp. 45-52. *In*: IOC/FAO Workshop on Recruitment in Tropical Coastal Demersal Communities. Cíudad del Carmen, Mexico, 21-25 April 1986. IOC Workshop *Rep.suppl.* (44):323 p. Intergovernmental Oceanographic Commission, UNESCO, Paris.

Degobbis, D. (1989). Increased eutrophication of the northern Adriatic Sea. *Mar.Poll.Bull.* 20(9):452-57.

Dethlefsen, V. (1980). Observations on fish diseases in the German Bight and their possible relation to pollution. *Rapp.P.-v.Réun.Cons.Int.Explor.Mer*(179):110-17.

Dethlefsen, V. (1989). Fish in the polluted North Sea. *Dana* (8):109-29.

D'Itri, F.M. (1985). Artificial reefs: marine and freshwater applications. Lewis Publishers, Inc. 589 p.

Dixon, J.A. and P.B. Sherman (1990). Economics of protected areas. Island Press. Washington D.C. 234 p.

Doering, P.H. *et al.* (1989). Structure and function of a model coastal ecosystem: silicon, the benthos and eutrophication. *Mar.Ecol.Prog.Ser.*(52):287-99.

Doty, M.S., J.F. Caddy, and B. Santelices (1987). Case studies of seven commercial seaweed resources. FAO *Fish.Tech.Pap.*(281):311 p.

Doulman, D.J. (1993). Community-based fishery management: towards the restoration of traditional practices in the South Pacific. *Mar.Pol.*17(2):108-17.

Drinkwater, K.F. (1986). On the role of freshwater outflow on coastal marine ecosystems - a Workshop Summary. NATO ASI Series, (G7):429-38. *In*: The Role of Freshwater Outflow in Coastal Marine Ecosystems. S. Skreslet (ed.). Springer-Verlag Berlin Heidelberg 1986.429-38 p.

Dugas, R., V. Guillory and M. Fischer (1979). Oil rigs and offshore sport fishing in Louisiane. Fisheries (U.S.). 4(6):2-9.

Dybern, B.I. (1972). Pollution in the Baltic. 15-23p. *In*: M. Ruivo (ed.). Marine Pollution and Sea Life. FAO, Rome.

Edwards, P. and R.S.V. Pullin (1990). Wastewater-fed aquaculture. *ICLARM Contribution 684*, 296 p.

Enell, M. and H. Ackefors (1991). Nutrient discharges from aquaculture operations in Nordic countries into adjacent sea areas. ICES Meeting Doc. CM 1991/F:56 (Mimeo):17 p.

Fallon Scura, L. (1993a). Review of recent experiences in integrated coastal management: ICLARM and URI. (Manuscript).

Fallon Scura, L. (1993b). Typological framework and strategy for integrated coastal fisheries management. (Manuscript):17 p.

Fan Zhijie and R.P. Coté (1991). Population, development and marine pollution in China. *Mar.Pol.*:210-19.

FAO (1978a). Some scientific problems of multispecies fisheries. Report of the Expert Consultation on management of multispecies fisheries. Rome, 20-23 September 1977. FAO *Fish.Tech.Pap.*(181): 46 p.

FAO (1978b). Mammals in the Seas. *FAO Fisheries Series* (5):264 p.

FAO (1984a). Report of the FAO World Conference on Fisheries Management and Development. FAO, Rome, Italy. 60 p. + seven Appendixes.

FAO (1984b). Expert Consultation on the Regulation of Fishing Effort (Fishing Mortality). FAO *Fish.Rep.*289 (Suppl. 1):145 p.

FAO (1986a). Study Report: Watershed management in Asia and the Pacific: needs and opportunities for action. *Tech.Rep.* FO:RAS/85/017:160 p.

FAO (1986b). Strategy for fisheries management and development. FAO, Rome, Italy:26 p.

FAO (1990). Report of the Expert Consultation on Large-scale Pelagic Driftnet Fishing. FAO *Fish.Rep.*(434):78 p.

FAO (1991a). Environment and sustainability in fisheries. COFI Document COFI/91/3: (2nd Draft). December 1990. FO:RAS/85/017:166 p.

FAO (1991b). Draft global strategy and agenda for action. FAO/Netherlands Conference on Agriculture and the Environment: Strategies and Tools for Sustainable Agriculture and Rural Development. 's-Hertogenbosch, The Netherlands, 15-19 April 1991.

FAO (1991c). Development of coastal areas and enclosed seas. *Res.pap.*(4):27p. Presented to UN Conference on Environment and Development, Rio de Janeiro, Brazil, 8-12 June 1992.

FAO (1991d). Fish for food and development. Strategy and Action Programmes for fisheries, 48 p.

FAO (1992a). FAO Report of the Technical Consultation on High-Seas Fishing.
Rapport de la Consultation technique sur la pêche en haute-mer.
Informe de la Consulta Técnica sobre la Pesca en Alta Mar.
FAO *Fish.Rep.*(484):85 p.

FAO (1992b). Review of the state of world fishery resources: Part 2 - Inland fisheries and aquaculture. FAO *Fish.Circ.*(710): Revision 8, Part 2:26 p.

FAO (1992c). Declaration of the International Conference on Responsible Fishing. Cancùn, Mexico, 6-8 May 1992. Document COFI/93/Inf. 7:5 p.

FAO (1992d). Report of the Expert Consultation on Utilization and Conservation of Aquatic Genetic Resources. Grottaferrata, Italy, 9-13 November. FAO *Fish.Rep.*(491):58 p. (Doc FIRI/R49).

FAO (1992e). Marine fisheries and the Law of the Sea: a decade of change. FAO *Fish.Circ.*(853):69 p.

FAO (1992f). Review of the state of world fishery resources: Part 1 - FAO *Fish.Circ.*(710): Revision 8, Part 1. 114 p.

FAO (1993a). Conservation and rational utilization of living marine resources, with special reference to responsible fishing. Document COFI/93/5. FAO, Rome, Italy:16 p.

FAO (1993b). World fisheries ten years after the adoption of the United Nations Convention on the Law of the Sea. Document COFI/93/4. FAO, Rome, Italy. 16p

FAO (1993c). High seas fishing. Document COFI/93/6. FAO, Rome, Italy. 11 p.

FAO (1993d). Fisheries research needs of developing countries. Document COFI/93/7. FAO, Rome, Italy. 9 p.

FAO (1993e). UNCED and its implications for fisheries. Document COFI/93/Inf. 8. FAO, Rome, Italy. 16 p.

FAO (1993f). The work of FAO in fisheries for 1994-95. Document COFI/93/9. FAO, Rome, Italy. 15 p.

FAO (1993g). Review of the state of world marine fishery resources. FAO *Fish.Tech.Pap.*(335):135 p.

FAO (1993h). Reference points for fisheries management: their potential application to straddling and highly migratory resources. FAO *Fish.Circ.*(864):52 p.

FAO (1993i). Report of the Expert Consultation on Utilization and Conservation of Aquatic Genetic Resources. FAO *Fish.Rep.*(491):58 p.

FAO (1993j). FAO/Japan Expert Consultation on the Development of Community-Based Coastal Fishery Management Systems for Asia and the Pacific. FAO *Fish.Rep.*(474):46 p.

FAO (1993k). World review of high seas and highly migratory fish stocks and straddling Fish Stocks. FAO *Fish.Circ.*(858):69p (Preliminary version).

FAO (1994a). FAO Expert Consultation on Fisheries Research, Rome, 12-15 April 1994: FAO *Fish.Circ.*(877):56 p.

FAO (1994b). Review of the state of world marine fishery resources. FAO *Fish.Tech.Pap.*(335):136 p.

FAO (1994c). World review of highly migratory species and straddling stocks. FAO *Fish.Tech.Pap.*(337):70 p.

FAO (1994d). Background information on the code of conduct for responsible fisheries. Technical Consultation on The Code of Conduct for Responsible Fisheries held in Rome, Italy, 26 September-5 October 1994. Doc. CCRF/TC/94/Inf.3: 9 p.

FAO (1994e). Agreement to promote compliance with international conservation and management measures by fishing vessels on the high seas. (Mimeo). Document D/T3168:11p. (English, French, Spanish, Arabic and Chinese).

FAO (1995a). Draft code of conduct for responsible fisheries (revised Secretariat Draft). FAO Committee on Fisheries. Document COFI/95/2:32 p.

FAO (1995b). The State of world fisheries and aquaculture. Special publication for the 21st Session of the Committee on Fisheries, March 1995, Rome, Italy. 57 p.

FAO (1995c). World fisheries: problems and prospects. FAO Committee on Fisheries. Document COFI/95/3:13 p.

FAO (1995d). The role of fisheries in food security. FAO Committee on Fisheries, Document COFI/95/Inf.10:12 p.

FAO (1995e). Report on the United Nations Conference on Straddling Fish Stocks and High Migratory Fish Stocks. FAO Committee on Fisheries, Document COFI/95/Inf.7:8 p.

FAO (1995f). Review of the state of world fishery resources: marine fisheries. FAO *Fish.Circ.*(884):165 p. FIRM/C884

FAO (1995g). *Guidelines* on the Precautionary Approach to Capture Fisheries and species introduction. FAO *Fish Tech.Pap.350 (Part 1):*47 p.

FAO/WHO (1993). List of final CODEX texts contained in CAC/VOL Series. *Doc.CX/GEN 93/1*: 20 p. (Mimeo) (Codex Alimentarius Commission, Rome, Italy).

Fischer, W and J.C. Hureau. (1985). FAO Species Identification Sheets for Fishery Purposes. Southern Ocean (Fishing Areas 48,58 and 88) (CCAMLR Convention Area), Vols I and II. Rome: FAO, 471p.

Flood, R.C. (1994). An annotated bibliography of community-based and traditional coastal fisheries management practices. FAO *Fish.Circ.*(876):59 p.

Flores Palimino, N. (1989). Incidencia de los fenómenos "El Niño" en la extracción de recursos pesqueros marinos de la pesquería peruana en el período 1958-1987. Memorias del Simposio Internacional de los Recursos Vivos y las Pesquerías en el Pacífico Sudeste, Viña del Mar, 9-13 mayo, 1988. Comisión Permanente del Pacífico Sur (CPPS), *Rev.Pacífico Sur*, (Número Especial):467-476.

Francis, R.C. (1990). Climate change and marine fisheries. Fisheries, (15)6:pp. 7-9,64.

Fogarty, M.J., M.P. Sissenwine and E.B. Cohen (1991). Recruitment variability and the dynamics of exploited marine populations. TREE 6(8):241-46.

Fuhrman, J.A. and D.G. Capone (1991). Possible biogeochemical consequences of ocean fertilization. *Limnol.Oceanogr.*36(8):1951-9.

Garcia, S.M. (1994a). The precautionary principle: its implications in capture fisheries management. Ocean and Coastal Management (22):99-125.

Garcia, S.M. (1994b). The Precautionary approach to fisheries with reference to straddling fish stocks and highly migratory fish stocks.
L'approche précautionneuse appliquée aux pêches dans le contexte des stocks chevauchants et des stocks de poissons grands migrateurs.
El enfoque precautorio para la pesca de poblaciones de peces que se encuentran dentro y fuera de las zonas económicas exclusivas y poblaciones de peces altamente migratorias. FAO *Fish.Circ.*(871):76 p.

Garcia, S.M. and A. Demetropoulos. (1986). Management of Cyprus fisheries. FAO *Fish.Tech.Pap.*(250):43 p.

Garcia, S.M., J.A. Gulland and E. Miles (1986). The new law of the sea and the access to surplus fish resources: bioeconomic reality and scientific collaboration. *Marine Policy*:192-200 p.

Garcia, S.M. and J. Majkowski. (1990). State of high seas resources. Paper submitted to 24th Annual Conference of the Law of the Sea Institute, (24-27 July 1992 Tokyo, Japan):52 p. (Mimeo)

GBRMPA (1992/93). Annual report of Great Barrier Reef Marine Park Authority. P.O. Box 1379 Queensland, Australia. 162 p.

Gerlach, S.A. (1988). Nutrients - an overview. 147-78. *In*: P.J. Newman and A.R. Agg (eds). Environmental Protection of the North Sea. Heinemann Professional Publishing, Oxford.

GESAMP (1982). The review of the state of health of the oceans. IMO/FAO/UNESCO-IOC/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on Scientific Aspects of Marine Pollution. Reports and Studies (15):108 p. UNESCO, Paris, France.

GESAMP (1983). Report of the Thirteenth Session, Geneva, Switzerland, 28 February - 4 March 1983. IMO/FAO/UNESCO/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on Scientific Aspects of Marine Pollution. Reports and Studies (18):50p. WMO, Geneva, Switzerland.

GESAMP (1984a). Marine pollution implications of ocean energy development. IMO/FAO/UNESCO/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on Scientific Aspects of Marine Pollution. Reports and Studies (20):45 p.

GESAMP (1984b). Thermal discharges in the marine environment. IMO/FAO/UNESCO-IOC/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on Scientific Aspects of Marine Pollution. Reports and Studies (24):44 p.

GESAMP (1986). Environmental capacity: an approach to marine pollution prevention. IMO/ FAO/ UNESCO-IOC/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on Scientific Aspects of Marine Pollution. Reports and Studies (30):49 p.

GESAMP (1987). Land-sea boundary flux of contaminants: contributions from rivers. IMO/FAO/UNESCO-IOC/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on Scientific Aspects of Marine Pollution. Reports and Studies (32):172 p.

GESAMP (1990). The state of the marine environment. IMO/FAO/UNESCO/WMO/ WHO/IAEA/UN/UNEP Joint Group of Experts on Scientific Aspects of Marine Pollution. Reports and Studies (39):111 p. UNEP, Nairobi, Kenya.

GESAMP (1991). Reducing environmental impacts of coastal aquaculture. IMO/FAO/UNESCO-IOC/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on Scientific Aspects of Marine Pollution. Reports and Studies (47):35 p. FAO, Rome, Italy.

GESAMP (1994). Anthropogenic influences on sediment discharges to the coastal zone and environmental consequences. IMO/FAO/UNESCO-IOC/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection. Reports and Studies (52):67 p.

GESAMP (1995). The invasion of the *Ctenophore Mnemiopsis leidyi* in the Black Sea. IMO/FAO/UNESCO-IOC/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on the Scientific Aspects of Marine Environmental Protection. Reports and Studies (58):*in press*.

GFCM (1990). General Fisheries Council for the Mediterranean. Report of the First Session of the Working Group on Artificial Reefs and Mariculture. Ancona, Italy. FAO Fisheries Report (428):162 p. FAO, Rome, Italy.

GFCM (1993). General Fisheries Council for the Mediterranean. Report of the Second Technical Consultation on Stock Assessment in the Black Sea. (Ankara, Turkey, 15-19 February 1993). *FAO Fish.Rep.*(495):173 p.

Gieskes, W.C. and G.W. Kraay. (1990). Transmission of ultraviolet light in the Wedell Sea: report on the first measurements made in Antarctic. Biomass Newsletter (12):12-14.

Gilpin, A. (1976). Dictionary of Environmental terms. University of Queensland Press. 191 p. *In*: Harden Jones (1994).

Gimbel, K.L. (ed) (1994). Limiting access to marine fisheries: keeping the focus on conservation. Center for Marine Conservation and World Wildlife Fund, US. Washington DC, USA: 316 p.

Glasser, J.W. (1978). The effect of predation on prey resource utilization. *Ecology* 59(4):724-32.

Goda, I. (1991). Environmental Management and Appropriate Use of Enclosed Coastal Seas - EMECS'90. *Mar.Pollut.Bull.*(23):812 p. (Pergamon Press).

Gon,O. and P.C.Heemstra, (eds).(1990). Fishes of the Southern Ocean. J.L.B. Smith Institute of Ichthyology, Private Bag 1015, Grahamstown 6140, South Africa.

Gordon, H.S. (1954). The economic theory of a common property resource: the fishery. *J.Polit.Econ.*62(2):124-42.

Grassle, J.F., P. Laserre, A.D. McIntyre and G.C. Ray (1990). Marine biodiversity and ecosystem function. A proposal for an international programme of research. IUBS/SCOPE/UNESCO Biology International; Union of Biology and Sciences: Special Issue (23):19 p.

Gough, J. and T. Kenchington (1995). A glossary of fisheries science. Communications Branch, Dept. Fisheries and Oceans, P.O. Box 550, Halifax, N.S. B3j 2S7, Canada:47 p.

Grigg, R.W. and S.J. Dollar (1988). Natural and anthropogenic disturbance on coral reefs. *In*: coral reef ecosystems. Elsevier Press, Amsterdam, The Netherlands.

Gulland, J.A. (1977). Fish population dynamics. J. Wiley, London.

Gulland, J.A. (1980). Some problems of the management of shared stocks. FAO *Fish.Tech.Pap.*(206):22 p.

Hallegraeff, G.M. and J.L. MacLean (1989). Biology, epidemiology and management of Pyrodenuism and tides. *ICLARM Conf.Proc.* (Brunei Danusalem, 23 May 1989), (21):286 p.

Hamilton, L.S. and S.C. Snedaker (1984). Handbook for mangrove area management. UNESCO, Paris, 123 p.

Hannson, S. (1985). Effects of eutrophication on fish communities, with special reference to the Baltic Sea - a literature review. *Rep.Inst.Freshw.Res.*(62):36-56. Drottningholm.

Hansson, S. and L.G. Rudstam (1990). Eutrophication and Baltic fish communities. *Ambio* 19(3):123-25.

Harden-Jones, F.R. (1994). Fisheries ecologically sustainable development: Institute of Antarctic and Southern Ocean Studies (IASOS), Hobart, Tasmania: 205 p.

Hardin, G. (1968). The tragedy of the commons. *Science* (162) 3859:1243-48.

Hayton, R.D. (1990). The freshwater/maritime interface: legal and institutional aspects. *FAO Legislative Study* (46):100 p.

Heide-Joergensen, M.P., T. Haerkoenen and P. Aeberg (1992). Long-term effects of epizootic in harbor seals in the Kattergat-Skugerrak and adjacent areas. *Ambio.* (21)8:511-516.

Hey, E., W.T. Burke, D. Ponzoni and K. Sumi (1991). The regulation of driftnet fishing on the high seas: legal issues. *FAO Legislative Studies* (47):83 p.

Hilborn, R. and C.J. Walters (1992). Quantitative fisheries stock assessment: choice, dynamics and uncertainty. Chapman and Hall, 570 p.

Holligan, P.M. and Kirst G.-O. (1989). Marine algae as a source of dimethylsulphide emissions to the atmosphere. 64-9. *In*: The Ocean as a Source and Sink for Atmospheric Constituents. Final Report of SCOR Working Group (72). UNESCO Technical Papers in Marine Science (56):102p. UNESCO, Paris, France.

Holling, C.S. (1986). The resilience of terrestrial ecosystems and global change. *In*: W.C. Clark and R.E. Munn (Eds.) Sustainable Development of the Biosphere. Cambridge University Press, London, UK. 292-317.

Holmgren-Urba, D and T.M. Baumgartner. (1993). A 250-year history of pelagic fish abundances from the anaerobic sediments of the Central Gulf of California. CALCOFI Reports, (34):60-8 p.

Holt, S.J. and L.M. Talbot (1978). New principles for the conservation of wild living resources. *Wildlife Monogr.*(59):33 p.

Hoss, D.E. and G.W. Thayer (1994). The importance of habitat to the early life history of estuarine-dependent fishes. *Am.Fish.Soc.Symp.*(14):3-15.

Houde, E.D. and E.S. Rutherford (1993). Recent trends in estuarine fisheries: predictions of fish production and yield. *Estuaries* 16(2):161-76.

Howarth, R.W. (1993). Appendix A. The Role of nutrients in coastal waters. 137-58. *In*: "Managing Waste Water in Coastal Urban Areas". National Academy Press, Washington DC, USA.

Hughes, J.P. (1994). Catastrophes, phase shifts, and large-scale degradation of the Caribbean coral reef Science (265):1547-51.

Hunter, J.R., J.H. Taylor and H.G. Moser (1979). The effect of ultraviolet radiation on eggs and larvae of northern anchovy and Pacific mackerel. *Photochem.Photobiol.* (29):325-38 p.

ICES (1992a). Effects of extraction of marine sediments on fisheries. International Council for the Exploration of the Sea, Cooperative Research Report (182):78p. ICES, Copenhagen, Denmark.

ICES (1992b). Effects of harmful algal blooms on mariculture and marine fisheries. International Council for the Exploration of the Sea, Cooperative Research Report (181):38 p. ICES, Copenhagen, Denmark.

ICES (1994a). Report of the Working Group on Ecosystem Effects of Fishing Activities. ICES Working Group Report CM.1994/ASSESS/ENV:(1):109 p.

ICES (1994b). Report of the Study Group on Seabird/Fish interactions. ICES Working Group Report CM/1994/L:(3):119 p.

ICES (1995). ICES Code of Practice on the Introduction and Transfers of Marine Organisms 1994. *From* ICES Coop.Res.Rep. 204, Annex 3, Sept. 1994:5 p.

ICLARM (1992). ICLARM's strategy for international research on living aquatic resources management, the Philippines, 79p. + appendix: 30 p.

IOC/UNESCO/FAO (1980). Workshop on the Effects of Environmental Variation on the Survival of Larval Pelagic Fish. IOC Workshop Report (28):323 p.

IPCC (1992). Scientific assessment of climate change. IPCC Supplement, WMO-UNEP Intergovernmental Panel on Climate Change. WMO, Geneva, Switzerland. 24 p.

IPFC (1991). Symposium on artificial reefs and fish aggregating devices as tools for the management and enhancement of marine fishery resources. FAO Regional Office for Asia and the Pacific (RAPA) 1991(11):435 p.

IPFC (1994). Socio-economic issues in coastal fisheries management. FAO Regional Office for Asia and the Pacific (RAPA), Bangkok, Thailand 23-26 November 1993. RAPA publication 1994(8):442 p.

IUCN, UNEP and WWF (1980). World conservation strategy. World Conservation Organization, Gland, Switzerland. 48 p.

Ivanov, L. and R.J.H. Beverton (1985). The fisheries resources of the Mediterranean. Part 2. Black Sea. General Fisheries Council for the Mediterranean, Studies and Reviews (60):135 p.

Jefferson, T.A., S. Leatherwood and M.A. Webber (1993). Marine mammals of the world. FAO Species Identification Guide (FAO/UNEP).

Johannes, R.E. (1975). Pollution and degradation of coral reef communities. Chapter (2):13-62 p. *In*: Ferguson Wood and R.E. Johannes. Tropical Marine Pollution. Elsevier Oceanography Series, (12):192 p.

Jones, P.J.S. (1994). A review and analysis of the objectives of marine nature reserves ocean and coastal management (24):149-78 p.

Jones, O.A. and R. Endean (eds.) (1973). Biology and geology of coral reefs. Vol. 1 and 2. Academic Press, London, UK.

Kapetsky, J.M. (1984a). Report of consultation/seminar on coastal fishpond engineering, 4-12 Aug. 1982, Surabaya, Indonesia, Doc.SCS/GEN/82/42. South China Sea Fisheries Development and Coordination Programme.

Kapetsky, J.M. (1984b). Coastal lagoon fisheries around the world. Some perspectives on fisheries yields and other comparative fishery characteristics. GFCM Studies and Reviews, 61(1):97-140.

Kapetsky, J.M. (1985). Mangroves, Fisheries, and Aquaculture. 17-36. *In*: FAO *Fish.Rep.* (338) (Suppl.):87p. (Doc FIRD/R338 Suppl.).

Kapetsky, J.M., L. McGregor and H. Nanne (1987). A geographical information system and satellite remote sensing for aquaculture development. FAO *Fish.Tech.Pap.* (287):51 p.

Karentz, D. (1991). Ecological considerations of Antarctic ozone depletion. *Antarctic science.* 3(1):pp. 3-11.

Katona S. and H. Whitehead (1988). Are cetacea ecologically important? *Oceanogr.Mar.Biol.Ann.Rev.*, (26):553-68.

Kawasaki, T. (1983). Why do some pelagic fishes have wide fluctuations in their numbers? - biological basis of fluctuation from the viewpoint of evolutionary ecology:1065-1080. *In*: G.D. Sharp and J. Csirke (eds.). Reports of the Expert Consultation to Examine Changes in Abundance and Species Composition of Neritic Fish Resources. FAO *Fish.Rep.* 291(1):102 p.

Kenchington, R.A. and B.E.T. Hudson. (1988). Coral reef management handbook (2nd edition). UNESCO. (ISBN 92-3-102485-x):321 p.

Kerr, S.R. (1977). Structure and transformation of fish production systems. *J.Fish.Res.Bd.Can.*, 34(10):1989-93.

Ketchum, B.H.(ed.). (1983). Ecosystems of the world. 26. Estuaries and Enclosed Seas. Elsevier Scientific Publishing Company, 500 p.

Kiladis, G.N. and H.F. Diaz (1989). Global climatic anomalies associated with extremes in the Southern Oscillation. *J.Climate* 2:1069-1090.

Knox, G.A. and T. Miyabara (1984). Coastal zone resource development and conservation in Southeast Asia. UNESCO East-West Centre, Jakarta Pusat, Indonesia, 182 p.

Kock, K-H, (1992). Antarctic fish and fisheries. Cambridge University Press, 359p

Kraft, C.E. (1992). Estimates of phosphorus and nitrogen cycling by fish using a bioenergetics approach. *Can.J.Fish.Aquat.Sci.* (49):2596-2604.

Krug, A. (1993). Drainage history and land use pattern of a Swedish river system - their importance for understanding nitrogen and phosphorus load. Hydrobiologia (251):285-96.

Kullenberg, G., N. Andersen and M. Cole (1993). Global ocean observing system. *In*: Coastal Zone '93. Proceedings, 8th Symposium on Coastal and Ocean Management. 2986-3000. New Orleans, Louisiana, USA, July 1993.

Larkin, P.A. (1977). An epitaph for the concept of maximum sustainable yield. *Trans.Amer.Fish.Soc.* (106):1-11.

Lehtonen, H. and M. Hilden (1980). The influence of pollution on fisheries and fish stocks in the Finnish part of the Gulf of Finland. *Finn.Mar.Res.* (247):110-23.

Lelek, A. (1989). The Rhine river and some of its tributaries under human impact in the last two centuries. 469-87. *In*: D.P. Dodge (ed.) Proceedings of the International Large River Symposium. *Can.Spec.Publ.Fish.Aquat.Sci.* (106).

Lenanton, R.C.J. and I.C. Potter (1987). Contribution of estuaries to commercial fisheries in temperate Western Australia and the concept of estuarine dependence. Estuaries 10(1):28-35.

Li, H.W. and P.M. Moyle (1981). Ecological analysis of species introductions into aquatic systems. *Trans.Am.Fish.Soc.* (110):772-82.

Linden, O. (1990). Human impacts on tropical coastal zones. *Nature and Resources*, Volume 26(4):3-11.

Liss, P.S. (1989). Methane and light non-methane hydrocarbons. 77-80. *In*: The Ocean as a Source and Sink for Atmospheric Constituents. Final Report of SCOR Working Group 72. UNESCO *Tech.Pap.Mar.Sci.* (56):102p. UNESCO, Paris, France.

Liss, P.S. and W.G.N. Slinn (eds.) (1983). Air-sea exchange of gases and particles. D. Reidel, Dordrecht, Holland. 299-405.

Lluch-Belda, D., R.A. Schwartzlose, R. Serra, R.H. Parrish, T. Kawasaki, D. Hedgecock and R.J.M. Crawford (1992). Sardine and anchovy regime fluctuations of abundance in four regions of the world oceans: a workshop report. *Fish.Oceanogr.* (1):4:339-347.

Maclean, J.L. (1988). Blast fishing and poisening threaten the Philippines' last undersea wilderness area. NAGA, 11(4):pp. 14-15.

MacNae, W. (1974). Mangrove forests and fisheries. Indian Ocean Programme/Indian Ocean Fishery Commission. Document IOFC/DEV/74/34:35.

Maguire, D.J., M.F. Goodchild and D.W. Rhind (1991). Geographical information systems: principles and applications. Longman Scientific and Technical. (Vol. (1): Principles 649 p.; Vol. 2: Applications 447 p.).

Mahon, R. (ed.) (1987). Report and proceedings of the expert consultation on shared fishery resources of the Lesser Antilles. FAO *Fish.Rep.* (383):278 p.

Mann, K.H. and J.R.N. Lazier (1991). Dynamics of marine ecosystems. Blackwell Scientific Publications:466 p.

Marashi, S.H. (1993). Activities of regional fishery bodies and other international organizations concerned with fisheries. FAO *Fish.Circ.* (807):57 p. Rev 1.

Marten, G.G. and J.J. Polovina (1982). A comparative study of fish yields from various tropical ecosystems. *In*: Theory and Management of Tropical Fisheries, Pauly, D. and G.I. Murphy (ed.), Manila. 255-85.

Martin, J.H., R.M. Gordon, S.E. Fitzwater and W.W. Broenkow (1989). VERTEX phytoplankton/iron studies in the Gulf of Alaska. *Deep Sea Res.* (36):649-80.

Martin, J.-M., J.D. Burton, and D. Eisma (eds.) (1982). River inputs to ocean systems. Proceedings of a SCOR/ACMRR/ECOR/IAHS/UNESCO/CMG/IABO/IAPSO Review and Workshop, FAO, Rome, Italy, 1979. UNESCO, Paris, France. 384 p.

Martin, J.-M. and V.V. Gordeev (1986). River input to the ocean system: a reassessment. *In*: Proceedings of a Scientific Workshop on Estuarine Processes. 203-40. UNESCO/IOC/CNA, Lisbon, Portugal, 1986.

May, R.M., J.R. Beddington, C.W. Clark, S.J. Holt and R.M. Laws (1979). Management of Multispecies Fisheries. *Science* (203):267-77.

McHugh, J.L. (1976). Estuarine fisheries: are they doomed? 15-27. *In*: M. Wiley (ed.). Estuarine Processes, Vol. 1, Academic Press N.Y.

McIntyre, A.D. and T.B. Pearce (eds.) (1980). Biological effects of marine pollution and the problems of monitoring. ICES *Rapp.p.v.Réun.Cons.Int.Explor.Mer.*(179):346 p.

McClelland, G., R.K. Misra and D.J. Marcogliese (1983). Variations in abundance of larval aniskines, sealworm (*Phocanema decipiens*) and related species in Scotian shelf (4Vs and 4W) Cod and Flatfish. *Can.Tech.Rep.Fish.Aquat.Sci.*(1202):27 p.

Meade, R.H. (1981). A cautionary note on the absence of steady state between soil erosion, sediment transport in rivers, and the delivery of river sediment to the oceans. 309-10. *In*: River Inputs to Ocean Systems (Martin, J.-M., J.D. Burton, D. Eisma, eds.): Proceedings of a SCOR/ACMRR/ECOR/IAHS/UNESCO/CMG/ IABO/IAPSO Review and workshop held in FAO, Rome, Italy 26-30 March 1979:384 p.

Mee, L.D. (1992). The Black Sea in crisis: a need for concerted international action. *Ambio* (21):278-86.

Mepham, R.H. and T. Petr (eds.) (1987). Papers contributed to the Workshop on strategies for the management of fisheries and aquaculture in mangrove ecosystems. FAO *Fish.Rep.* (370) Suppl.:248 p.

Mellergaard, S. and E. Nielsen (1990). Fish disease investigations in Danish coastal waters with special reference to the impact of oxygen deficiency. ICES, C.M. 1990/E:6 Marine Environmental Quality Committee. 21 p. (Mimeo).

Miller, D.G.M. and I. Hampton (n.d.). Biology and ecology of the Antarctic krill (*Euphausia superba* Dana): a review. BIOMASS Sci.Ser. Cambridge-UK, SCAR-SCOR Report Vol. 9; 166p.

Milliman, J.D. (1981). Transfer of river-borne particulate material to the oceans. 5-12. *In*: River Inputs to Ocean Systems (Martin, J.-M., J.D. Burton, D. Eisma, eds.): Proceedings of a SCOR/ACMRR/ECOR/IAHS/UNESCO/CMG/IABO/IAPSO Review and workshop held at FAO, Rome, Italy, 26-30 March 1979, 384 p.

Milliman, J.D.,Y.S. Qian, and Y. Saito (1987). Man's influence on the erosion and transport of sediment by Asian rivers: the Yellow River example. *J.Geol.* (94):751-62 p.

Mitchell, E.D. (1973). The States of the World's whales. *Nature Canada,* (2)4:9-27.

Murty, T.S. (1977). Seismic sea waves: Tsunamis. *Bulletin of the Fisheries Research Board of Canada*, 198:337.

Murty, T.S. (1984). Storm surges: meteorological ocean tides. *Can.Bull.Fish.Aquat.Sci.* (212):897.

Nagasaki, F. and S. Chikuni (1989). Management of multispecies resources and multi-gear fisheries: experience in coastal waters around Japan. FAO *Fish.Tech.Pap.* (305):68 p.

Neu, H.J.A. (1975). Runoff regulation for hydropower and its effects on the ocean environment. *Can.J.Civil.Eng.* (2):583-91.

Norse, E.A. (1993). Global marine biological diversity. Island Press, 388 p.

Northcote, T.G. (1980). Fish in the structure and function of freshwater ecosystems: a "top-down" view. *Can.J.Fish.Aquat.Sci.* 45(2):361-79.

Northridge, S.P. (1984). World review of interactions between marine mammals and fisheries. FAO *Fish.Tech.Pap.* (251):190 p.

Northridge, S.P. (1991). An updated world review of interactions between marine mammals and fisheries. FAO *Fish.Tech.Pap.* (251) (Suppl.1):58 p.

NSF/NASA (1989). Ocean colour from space. (A folder of remote sensing imagery and text, prepared by the NSF/NASA-sponsored US Global Ocean Flux Study Office, Woods Hole Oceanographic Institution, Woods Hole, MA 02543.

Odum, E.P. (1971). Fundamentals of Ecology. 3rd Ed. Publisher: Sacenders: 574 p.

Ogden, L. (ed.) (1989). Proceedings of the Second Western Atlantic Turtle Symposium. NOAA Tech. Memorandum, NMFS-SEFC-226:40.

Olsson, M. (1994). Effects of persistent organic pollutants on biota in the Baltic Sea. *Arch.Toxicol.* 16 (Suppl.):43-52.

Panayotou, T. (1982). Management concepts for small-scale fisheries: economic and social aspects. FAO *Fish.Tech.Pap.* (228):53.

Pastorok, R.A. and G.R. Bilyard. (1985). Effects of sewage pollution on coral reef communities. *Mar.Ecol.Prog.Ser.* (21):175-89.

Pauly, D. (1979a). Theory and management of tropical multispecies stocks: a review, with emphasis on the southeast Asian demersal fisheries. ICLARM *Stud.Rev.* (1):35 p.

Pauly, D. (1979b). Biological overfishing of tropical stocks. ICLARM News (1)2(3):3-4.

Pauly, D. and G.I. Murphy (eds.) (1982). Theory and Management of Tropical Fisheries. ICLARM Conference Proceedings (9):360 p.

Pauly, D., P. Muck, J. Mendo and I. Tsukayama (1989). The Peruvian upwelling ecosystem: dynamics and interactions. *ICLARM Conf.Proc.* (18):438 p.

Pauly, D. and V. Christensen (1995). Primary production required to sustain global fisheries. *Nature*, Vol.374, 16 March 1995:255-257.

Phillips, M.J., C. Kwei Lin and M.C.M. Beveridge (1993). Shrimp culture development and the environment: Lessons from the world's most rapidly expanding warmwater aquaculture sector. pp. 171-197. *In*: R.S.V. Pullin, H. Rosenthal and J.L. Maclean (eds.). Environment and Aquaculture in Developing Countries. *ICLARM Conf.Proc.* (31):359 p.

Pielou, E.C. (1975). Ecological indices. Wiley Interscience, New York, USA.

Pimm, S.L. (1984). The complexity and stability of ecosystems. *Nature* 307:321-26.

Pollnac, R.B. and M.T. Morrissey (eds.) (1989). Aspects of small-scale fisheries development. ICMRD Publication, University of Rhode Island USA, 152 p.

Pope, J.G. and B.J. Knights (1982). Comparison of length distributions of combined catches of all demersal fishes in surveys in the North Sea and at Faroes Bank. 116-18. *In*: Mercer, M.C. (ed.). Multispecies Approaches to Fisheries Management Advice.

Por, F. D. (1968). Lessepsian migration. Ecological Studies (23):228 p. Sringer-Verlag.

Portman, J.E. (1989). The chemical pollution status of the North Sea. Dana (8):95-108.

Prospero, J.M. (1981). Eolian transport to the world ocean. *In*: C. Emiliani (ed.) The Sea. (7). The Oceanic Lithosphere. 801-74. Wiley, New York, USA.

Pucher-Petkovic, T. *et al.* (1988). Time series of productivity parameters indicating eutrophication in the middle Adriatic waters. 41-50. *In*: Caddy, J. and M. Savini (eds.) 1988. FAO *Fish.Rep.* (394):306 p.

Pugh, D.T. (1987). Tides, surges and mean sea-level: a handbook for engineers and scientists. Wiley & Sons, New York, USA. 742 p.

Pullin, R.S.V. (1991). An overview of environmental issues in developing country. Aquaculture development. *In:* ICLARM Conference proceedings 31.

Pulos, L. (1986). Second International Conference on Ciguatera: selected papers. *Mar.Fish.Rev.* 48(4):93 p.

Ramanathan, V. (1988). The Greenhouse theory of climate change: a test by an inadvertent global experiment. *Science*, Vol. 240:293-40.

Rapport, D.J., H.A. Regier and T.C. Hutchinson. (1985). Ecosystem behaviour under stress. *Am.Nat.* 125(5):617-38.

Reggio, V.C., Jr. (1987). Rigs-to-reefs. Fisheries (U.S.) Vol. 12 (4):2-7.

Regier, H.A. (1973). Sequence of exploitation of stocks in multispecies fisheries in the Great Lakes. *J.Fish.Res.Bd.* Canada, 30(12).

Regier, H.A. (1979). Changes in species composition of Great lakes fish communities caused by man. *In:* Proceedings of Forty-fourth North American Wildlife Conference. 558-66.

Regier, H.A., P. Tuunainen, Z. Russek and L.E. Persson. (1988). Rehabilitative redevelopment of the fish and fisheries of the Baltic Sea and the Great Lakes. *Ambio*, 17(2):121-30.

Regier, H.A. and H.F. Henderson (1973). Towards a broad ecological model of fish communities and fisheries. *Trans.Am.Fish.Soc.*102(1):56-72.

Regner, S. and M. Gacic (1974). The fluctuations of sardine catch along the Eastern Adriatic coast and solar activity. Acta Adriatica 15(11):15.

Reish, D.J. (1980). Effects of domestic wastes on the benthic marine communities. *Helgol-Meeresunters 33*, pp. 377-383.

Rice, J. (in press). Food web theory, marine food webs, and what climate change may do to northern marine fish populations. *In*: Beamish, R.J. (ed.): Proceedings of the International Symposium on Climate Change and Northern Fish Populations. *Can J.Fish.Aquat.Sci.* (in press)

Richardson, K. (1989). Algal blooms in the North Sea: the good, the bad and the ugly. Dana, (8):83-93.

Ricker, W.E. (1975). Computations and interpretation of biological statistics of fish populations. *Bull.Fish.Res.Board Ca.* (191):382 p.

Ridgeway, S.H. and R. Harrison (eds.). (1985). Handbook of marine mammals. Academic Press.

Robson, D.S. (1966). Fishing power of individual ships. ICNAF *Res.Bull.* (3): 5-14.

Rodhouse, P.G. (1989). Antarctic cephalopods - a living marine resource? AMBIO 18(1): p 56- 59.

Rosemarin, A. (ed.) (1990). Current status of the Baltic Sea. *Ambio Special Report* (7):24 p.

Ruddle, K. (1987). Administration and conflict management in Japanese coastal fisheries. FAO *Fish.Tech.Pap.* (273):93 p.

Saclauso, C.A. (1989). Brackish water aquaculture: threat to the environment? *NAGA ICLARM Quarterly*, 12(3)6-8.

Saila, S.B. (1983). Importance and assessment of discards in commercial fisheries. FAO *Fish.Circ.* (765):62 p.

Savini, M.J. (1991). Summary information on the role of international fishery bodies with regard to the conservation and management of living resources of the high seas. FAO *Fish.Circ.* (835) rev.1:57 p.

SCAR(1993). The role of the Antarctic in global change: an international plan for a regional research programme. The Scientific Committee on Antarctic Research, Cambridge UK: 57p.

Sharp, G.D. and D.R. McLain (1993). Fisheries, el Niño - Southern Oscillation and Upper-Ocean temperature records: an eastern Pacific example. *Oceanography* (6)1:13-22.

Sherman, K. and L.M. Alexander (eds.). (1986). Variability and management of large marine ecosystems. AAAS Selected Symposium 99. Westview Press, Boulder, CO, USA. 319 p.

Sherman, K., L.M. Alexander and B.D. Gold. (1990). Large marine ecosystems: patterns, processes and yields. AAAS Symposium, AAAS Publishers, Washington, D.C., USA.

Sherman, K. and A.R. Solow. (1992). The changing states and health of a large marine ecosystem. Paper submitted to International Council for the Exploration of the Sea. C.M. 1992/L:38, Session V. ICES, Copenhagen, Denmark. 31 p.

Shiganova, T.H., B. Ozturk and A. Dede (1993). Distribution of the ichthyo- and jelly plankton in the Sea of Marmara in October 1992. Annex VII (p. 141-147). *In: FAO Fish.Rep.*(495):199 p.

Shokita, S., K. Kakazu, A. Tomori and T. Toma (1991). Aquaculture in tropical areas. Midori Shobo Co. Ltd., 360 p.

Simard, F. (1986). Un nouveau plan de développement pour les pêches au Japon: la marinovation. *La Pêche maritime 65^e année*. (1297):260-70.

Simon, D. (1989). Sustainable development: theoretical construct or attainable goal? *Environmental Conservation* 16(1):41-8.

Sinclair, M. (1988). Marine populations. An essay on population regulation and speciation. Washington Sea Grant Program. 252 p.

Siniff, D.B. (1988). An overview of the ecology of Antarctic seals. Am. Zool. 31(1): p 143-149

Sissenwine, M.P. (1978). Is MSY an adequate foundation for optimum yield? Fisheries 3(6):22-4.

Smith, P.J. (1994). Genetic diversity of marine fisheries resources: possible impacts of fishing. FAO *Tech.Pap.*(344):53 p.

Smith, W.D. and A. Vallega (eds.) (1990). The management of semi-enclosed seas: the emerging global pattern and the Ligurian case. International Geographical Union\Commission on Marine Geography.

Smith, I.R. and T. Panayotou (1984). Territorial use rights and economic efficiency: the case of the Philippine fishing concessions. FAO *Fish.Tech.Rep.* (245):17 p.

Smith, I.R., D. Pauly and A.N. Mines (1983). Small-scale fisheries of San Miguel Bay, Philippines: Options for Management and Research. ICLARM *Tech.Rep.* (11):78 p.

Snieszko, S.F. (1974). The effects of environmental stress on outbreaks of infectious diseases in fishes. *J.Fish.Biol.* (6):197-208.

Soepadmo E., A.N. Rao and D.J. MacIntosh (1984). Proceedings of the Asian Symposium on Mangrove environment; Kuala Lumpur, 25-29 August 1980; 828 p.

Sorokin, Y.I. (1983). The Black Sea. *In*: Ecosystems of the World. Vol. 26. Estuaries and Enclosed Seas, P.H. Ketchum (ed.). Amsterdam, Elsevier, 253-91.

Sorokin, Y.I. (1993). Essay on ecological situation in the Black Sea, pp. 69-77 (Annexe II). *In*: FAO *Fish.Rep.*(495):199 p.

Stroud, R.H. (ed.). (1992). Stemming the tide of coastal fish habitat loss. Marine Recreational Fisheries (14). *In:* Proceedings of a Symposium on Conservation of Coastal

Fish Habitat Baltimore, Maryland, 7-9 March 1991. National Coalition for Marine Conservation. Savanah, GA.

Tacon, A.G.J. (1993). Feed ingredients for warmwater fish: Fish meal and other processed feedstuffs *FAO Fisheries Circular*. No. 856. Rome, FAO. 64 p.

Tacon, A.G.J. (1994). Feed ingredients for carnivorous fish species: Alternatives to fishmeal and other fishery resources. *FAO Fisheries Circular* No. 881. Rome, FAO. 35 p.

Tatara, K. (1991). Utilization of the biological production in eutrophicated sea areas by commercial fisheries and the environmental quality standard for fishing ground. *Mar.Poll.Bull.*(23):315-320.

Tilmant, J.T. (1987). Impacts of recreational activities on coral reefs. 195-214. *In*: Salvat, B. (ed.). Human Impacts on Coral Reefs: Facts and Recommendations. Antenne Museum EPHE, French Polynesia. 253 p. (In English with summaries in French).

Tisdell, C.A. ( 1982). Environmental conservation: economics, ecology, and ethics. *Environmental Conservation*. 107-12.

Turner, R.E. (1987). Relationships between coastal wetlands, climate, and penaeid shrimp yields. 267-75. *In*: IOC/FAO Workshop on Recruitment in Tropical Coastal Demersal Communities. Ciudad del Carmen, Mexico, 21-25 April 1986. Workshop Report (44) Suppl:323 p.

Turner, G.E. (1988). Codes of practice and manual of procedures for consideration of introductions and transfers of marine and freshwater organisms. *EIFAC Occasional Paper* (23):44 p.

UNCED (1992). Agenda 21 Chapter 17: Protection of the oceans, all kinds of seas, including enclosed and semi-enclosed seas, and coastal areas and the protection, rational use and development of their living resources. (Rio Conference, 1992). United Nations Conference on Environment and Development, Conches, Switzerland. 44 p. (Mimeo).

UNDP/UNESCO (1987). Mangroves of Asia and the Pacific: Status and management. Natural Resources Management Center, Quezon City, Metro Manila. JMC Press Inc. 538 p.

UNEP (1990a). Technical Annexes to the Report on the State of the Marine Environment. Regional Seas Reports and Studies, (114/2):676 p.

UNEP (1990b). The State of the marine environment. Reports and studies (39):11 p.

UNEP (1994). The Impacts of Climate on Fisheries. UNEP Environment Library No. 13:36 p.

UNEP/UNESCO/FAO (1988). Eutrophication on the Mediterranean sea. Receiving Capacity and Monitoring of Long-Term Effects. *Mediterranean Action Plan Tech.Rep.*(21):200.

UNEP-IUCN (1988). Coral reefs of the world. Vol. 1, 2 and 3. UNEP Regional Seas Directories and Bibliographies. IUCN, Gland, Switzerland and Cambridge, UK; UNEP, Nairobi, Kenya. Vol.1, Atlantic and Eastern Pacific, 373 p., 38 maps. Vol. 2, Indian Ocean, Red Sea and Gulf, I + 389 p., 36 maps. Vol. 3, Central and Western Pacific, 329 p., 30 maps.

UNESCO (1986). Human induced damage to coral reefs. UNESCO reports in marine science Vol. (40):180 p.

United Nations (1983). The Law of the Sea. United Nations Convention on the Law of the Sea, with Index and Final Act of the Third United Nations Conference on the Law of the Sea. United Nations, New York, USA. 224 p.

United Nations (1985). Estimates and projections of urban, rural and city populations, 1950-2025. The 1982 Assessment. United Nations, New York, USA.

United Nations (1992). The Law of the Sea: The Regime for High-Seas Fisheries - Status and Prospects. UN Publications, Sales No. E.92.V.12. United Nations, New York, NY, USA, 48 p.

United Nations (1994). Report of the International conference on Population and Development, Cairo, Egypt, 5-13 September 1994. Preliminary version:155 p.

United Nations (1994). Convention on biological diversity. Text and Annexes. The Interim Secretariat for the Convention on biological diversity, Geneva Executive Center, CP 356. CH-1219 Chatelaine, Switzerland.

Ursin, E. (1982). Stability and variability in the marine ecosystem. *Dana* 12:51-67.

Ursin, E. (1984). The tropical, the temperate, and the Arctic seas as media for fish production. *Dana* (3):43-60

Ursin, E. and E. Andersen (1978). A model of the biological effects on eutrophication in the North Sea. *Rapp.p.-v.Réun.Cons.Int.Explor.Mer.* (172):366-77.

van Bennekom, A.J. and W. Salomons (1981). Pathways of nutrients and organic matter from land to oceans through rivers. *In*: Martin, J.M., J.D. Burton and J.D. Eisma (eds.) (1982). River inputs to ocean systems. Proceedings of a SCOR/ ACMRR/ ECOR/ IAHS/ UNESCO CMG/ IABO/ IAPSO Review and Workshop: FAO Rome, 6-30 March, 1979. 384 p.

Van Dolah, R.F., P.H. Wendt and M.V. Livisen (1991). A study of the effects of shrimp trawling on benthic communities in two South Carolina sounds. *Fish.Res.* (12):139-57.

Van Houtte, A. (1994). The legal regime of aquaculture. FAO *Aquacult.Newsl.* (7):10-15.

Vollenweider, R.A., R. Marchetti and R. Viviani (eds.). (1992). Marine coastal eutrophication. Proceedings of an International Conference on Marine Coastal Eutrophication - The response of marine traditional systems to human impact: problems and perspectives for restoration. Bologna, Italy, 21-24 March 1990, 1310 p.

Volovik, S.P., V.G. Dubinina and A.D. Semenov. (1993). Hydrobiology and dynamics of fishing in the sea of Azov. Part 1, p. 1-58. *In:* GFCM 1993. Fisheries and Environmental Studies in the Black Sea System, GFCM Studies and Reviews (64):58 p.

Voss, G.L. (1973). Cephalopod resources of the world. FAO *Fish.Circ.* (149):79 p.

Wahby, S.D. and N.F. Bishara (1981). The effect of the river Nile on Mediterranean water, before and after the construction of the high dam at Aswan. 311-18. *In*: River inputs to ocean systems (Martin, J.-M., J.D. Burton and D. Eisma, eds.): Proceedings of a SCOR/ACMRR/ECOR/IAHS/UNESCO/CMG/IABO/IAPSO Review and workshop held at FAO, Rome, Italy, 26-30 March 1979:384 p.

Ward, J.V. and J.A. Stanford (1989). Riverine ecosystems: the influence of man on catchment dynamics and fish ecology, pp. 56-64. *In*: D.P. Dodge (ed.). Proceedings of the International Large River Symposium. *Can.Spec.Publ.Fish.Aquat.Sci.* (106).

Welcomme, R.L.K. (in press). Relationships between fisheries and the integrity of river systems. *In*: Proceedings of International Conference on Sustaining the ecological integrity of large floodplain rivers. La Crosse, Wisconsin, 12-15 July 1994.

White, A.W., M. Anraky and K-K Hooi (eds.) (1984). Toxic red tides and shell fish toxicity in Southeast Asia. (Proceedings of a consultative meeting: Singapore, 11-14 September 1984). Southeast Asian Development Center, Bangkok and International Development Research Centre, Ottawa, Document ISBN-9971-88-061-X:133 p.

Williams, W.D. and N.V. Aladin (1991). The Aral Sea: Recent limnological changes and their conservation significance. *Aquat.Conserv.Mar.Freshw.ecosystems* (1):3-13.

Williamson, P. (1992). Global change: reducing uncertainties. *In*: International Geosphere-Biosphere Programme (of the International Council of Scientific Unions). IGBP Secretariat, Royal Swedish Academy, Stockholm, Sweden. 40 p. Coastal connections. 19-21 pp.

Willmann, R. and D. Insull (1993). Integrated Coastal Fisheries Management. *Ocean and Coastal Management* (21):285-302.

World Bank (1992). A Study of International Fisheries Research. Policy and Research Series 19. World Bank (International Bank for Reconstruction and Development), Washington DC, USA. 103 p.

Wulff, F., A. Stigebrandt and L. Rahm. (1990). Nutrient dynamics of the Baltic sea. *Ambio* 19(3):126-33.

Zaitsev, Yu.P. (1993). Impact of eutrophication on the Black Sea fauna. Part 2. *In*: GFCM 1993. Fisheries and Environmental Studies in the Black Sea System. GFCM Studies and Reviews (64):59-86.

# ANNEX I

# SOME RECENT CHANGES IN PERCEPTION OF MARINE RESOURCES AND ENVIRONMENT: A SHORT GLOSSARY OF RELEVANT CONCEPTS

*"The Working Party concluded that many terms and concepts were used in fisheries management. Often these terms mean different things to different people. When this happens time is wasted in a preoccupation with the terms and concepts rather than a direct address of the issues" (Harden Jones, 1994).*

## INTRODUCTION

The period since the Second World War has not only seen the increasing impact of human activities on a domain, the ocean, once thought impervious to such activities but, especially over the last two decades, a progressive development of our perception of oceanic processes as they affect man and living resources. A specialized vocabulary is evolving to deal with these issues, and some key terms are given here for those interested. The text as presented borrows freely from two other sources such as Dawson (1980), Harden Jones, (1994) and Gough and Kenchington (1995), to whom the reader is referred for more specialized fisheries vocabulary.

**Age class**:
All of the fish in a stock that are of a particular age, such as all of the 3-year olds (An age class is often referred to as a cohort, and the new age class enterring the fishable population in a given year are referred to as the recruits).

**Artisanal Fisheries**:
Small scale fisheries which on a global scale provide employment to many fishers, involve a modest capitalization per head, and provide fish largely for consumption (as opposed to reduction to meal and oil).

**Biodiversity**:
Biodiversity, or biological diversity, refers to the variety of life on earth. Three levels of biological organisation, genetic, species and ecosystem, are reflected in a widely used hierarchical three-tiered description of biological diversity" (Working Party on the Conservation of Biodiversity as it relates to Ecologically Sustainable Development). A slightly different definition is found in UN (1994), which also includes a brief section on definitions.

**Biomass:**
The total weight of all the fish in a stock or other group, added together (Gough and Kenchington, 1995)

**Coastal Zone:**

A definition developed by CSIRO is as follows: "the coastal zone extends seawards to 12 nautical miles offshore or to the 100 meter (sic) depth isopleth, whichever is the furthest from shore (except where overriding legislation is involved), and extends landwards to include all coastal lands, at least to the limit of those local government areas adjoining tidal waters".

**Common Property:**

"Common property resources refer to resources held or used by all who choose to do so. The term is often used synonymously with "open access resources". A resource is common property when it is not or cannot be owned or used by an individual or individual-like entity to the exclusion of others" (Dawson, 1980).

**Community:**

"The commonwealth; the body politic" (Dr. Johnson's Dictionary).

"In ecology any naturally occurring group of different organisms sharing a particular habitat interacting with each other particularly through relationships while being relatively independent of other groups" (Gilpin 1976)."A biotic community is any assemblage of populations living in a prescribed area of physical habitat; it is an organised unit to the extent that it has characteristics additional to its individual and population components .... and functions as a unit through coupled metabolic transformations. It is the living part of the ecosystem" (Odum, 1971).

**Complexity:**

Experience with applying multispecies models in fishery management to date have been very limited and the problems encountered are of great complexity and constitute the present frontier in fisheries science, so that the application of these principles in management must be to some extent empirical. The immediate way forward in practical terms appears to be to recognize that areas of great biotic complexity or 'interconnectedness', such as coastal wetlands, coral reefs, sea grass beds and mangrove forests, need to be protected, not only because of their importance for habitat stabilization and storm protection, but because these and other habitats, such as estuaries, lagoons and narrow straits, are critical habitats or points of passage in the migration of some marine resources and, as such, need protection. It is precisely because of the complexity of marine systems and the difficulty of investigating and separating actions and reactions, that classical 'impact assessment' procedures have been less than successful, and this has led to the concept of the "precautionary approach" as applied to new human activities in the marine environment.

**Conservation:**

"The act of preserving; care to keep from perishing; continuance; protection" (Dr. Johnson's Dictionary).

"Conservation has been legally defined as the process of reaching a defined state of the resource (United Nations, 1958). An expansion of the definition has been proposed by Holt and Talbot (1978); conservation is seen as a component of management which, taking current and future values of the resources into consideration, regulates use to maintain the resource system in "desirable states". It is then necessary to identify what the specific "desirable states" are. Conservation is often confused with preservation in

its strictest sense, i.e. that of maintaining a pristine environment or non-utilisation of a resource. Rather it is preservation in the sense of preserving for future yields (Dawson, 1980).

"The management of human use of the biosphere so that it may yield the greatest sustainable benefit to present generations while maintaining its potential to meet the needs and aspirations of future generations. Thus conservation is positive, embracing preservation, maintenance, sustained utilisation, restoration, and enhancement of the natural environment" (IUCN, 1980).

"In an ecosystem context, any approach to conservation needs to take into account the effects of fishing on not only the target species, but also dependent and related species. The group agreed that while there is a need to begin development of appropriate approaches to the conservation of ecosystems, the priority for completing this task is lower than for finfish stocks" (CCAMLR, 1988)

"In the fisheries context a precautionary approach to conservation would be to adjust fishing mortality (through input and output controls) so that the spawning biomass, and thus the population or stock fecundity of the species or species-group of interest, did not fall below the level normally associated with an average of interest, did not fall below the level normally associated with an average of interest, did not fall below the level normally associated with an average recruitment (and thus a year-class of medium strength) under average conditions for survival". (Harden Jones, 1994).

**Developed Fishery:**

"A fishery operating at or near the level consistent with ecologically sustainable development and in accordance with a management plan" (from Harden Jones, 1994).

**Developing Fishery:**

"A fishery in which experimental or feasibility fishing is being undertaken to determine whether the resource can support a viable fishery consistent with ecologically sustainable development" (Harden Jones, 1994).

**Development**:

"The modification of the biosphere and the application of human, financial living and non-living resources to satisfy human needs and improve the quality of human life".

"In the context of ecologically sustainable development, progress towards desirable results rather than growth itself".

Develop/development and grow/growth have very different meanings: In Harden Jones (1994) these are distinguished: "to **grow** means to increase naturally in size through the addition of material through assimilation or accretion. To **develop** means to expand or realise the potentialities of; bring gradually to a fuller, greater or better state. In short, growth is quantitative increase in physical scale while development is qualitative improvement or unfolding of potentiality. An economy can grow without developing, or develop without growing, or both, or neither".

**Discards:**

"Discards or discard catch refers to part of the gross catch not used in any way but is thrown back into the waters as whole fish or whole organisms (in the case of invertebrates, amphibians, reptiles or mammals). This phrase is not to be confused with offal from the retained catch, which might also be thrown overboard. The term by-catch is used herein to define that part of the gross catch which is captured incidentally to the species towards which there is directed effort. Some, all or none of the by-catch may become the discard catch" (Saila, 1983).

**Diversity:**

Diversity indices are measures of evenness (variances of species' abundance distributions) and, in some cases, richness (the number of species in a system); they are therefore indifferent to species substitutions which may, however, reflect ecosystem stresses (such as may be due to high fishing intensity). The relative values of various diversity indices is still a matter of current ecological debate, since some perhaps give too much weight to dominant species, and others, likewise, to the presence of possibly occasional species in an ecosystem.

Indices based on the number of species in a given ecosystem may satisfactorily measure biodiversity (usually meaning the number of species in a given ecosystem), whereas those based on species' abundances may measure genetic diversity better. As our capacity to sample, to manage, and to develop sustainably, marine (and other) resources increases, the required effective measures of ecological, biological and genetic diversity will emerge as sharper management tools than they are at present.

**Equilibrium yield:**

The yield or catch that would in theory be taken every year by a certain amount of fishing effort, if the effort was kept steady year after year until the stock was "in balance" or "at equilibrium" with the total fishing effort exerted by the fleet. (We may note that this definition, although mathematically feasible and widely used by fish population scientists, in practise represents a dangerous concept: neither environment, recruitment or fishing effort are in equilibrium or at a "Steady State" as simple population theory would suggest. It may be precisely this assumption that leads to unprecautionary fisheries management!).

**Escapement:**

Originally used in salmon fisheries, but progressively more widely for other resources, to mean that percentage of fish which escape the fishery to reach the spawning grounds (i.e. the spawning stock).

**Fishing effort:**

The amount of fishing (often expressed on an annual basis) in units of (usually) boat days on the ground, or even in more detailed units such as number of trap hauls, or trawl hauls. Effort levels may be **nominal**: reflecting the simple total of effort units exerted on a stock in a given time period, or may be calibrated. For purposes of stock assessment, an attempt is usually made to calibrate effort so that it measures the

pressure exerted on the stocks, in which case it may be referred to as **fishing intensity**. Hence an attempt is made to determine the **fishing power** of units in the fleet by looking at their relative **CPUE (catch per unit of effort)** in order to determine their relative impact on the stock.

The fishing effort, after 'fishing power calibration' may be expressed in 'standard units' summed over all types of fishing gear/boat types fishing the stock; these standard units are equivalent to a certain rate of fishing mortality, which latter is the fundemental quantity that fisheries managers need to control. We may note that hidden increases in fishing power due to technological improvements (radar, depth sounders, increased fishermen skills as well as improved gear and horse power/capacity of vessels all can increase fishing mortality rate by increasing the fishing power, even if the nominal fishing effort level remains constant).

**Ghost Fishing:**

The accidental and random capture of aquatic species by fish netting (usually gill netting) that has been lost or thrown into the sea, usually by fishermen, and which floats and is transported by the currents. Such captures leads to needless destruction of marine fishes, mammals, birds and turtles, in particular.

**Interconnectedness:**

The concept that oceanic processes are directly coupled with short and long-term changes in the atmosphere makes the linkage between meteorology and oceanography a scientific frontier that requires priority attention before global modelling of living systems, climate change etc., can make major progress, and before forecasting of fishery yields, tsunamis, mariner's weather forecasts etc. can be improved.

With respect to the 'Theory of Fishing' as it applies to marine fisheries, the late 1970s and the 1980s have seen dramatic changes in perception, with a decline in reliance on stable-equilibrium, single-species approaches, in which factors intrinsic to the population (such as spawning stock size), were given precedence over a consideration of multispecies interactions in the context of a variable environment. The major priority remains, namely, how to exert controls on fishing effort or on access to resources with finite capacity to support exploitation, but it is clear that calculations of sustainable yield need to take into account linkages within the food web and the impacts of heavy fishing on other components than those harvested.

The importance of interconnectedness is evident in other respects also. Thus, the need for closer integration of research in oceanography, marine living resources, economics and sociology of coastal communities, and the broad range of human activities located in the coastal zone, and an interdisciplinary approach to research. A parallel interconnectedness is needed between government departments concerned with marine affairs and, at an international level, between UN and non-governmental agencies.

**Habitat:**

The environment in which the fish live. It includes everything that surrounds and affects its life: the temperature and depth of water, and kind of seabed. The term can even be extended to include the local food supply, predators and polluting effects. (A fishery is not usually thought of as part of a fish's habitat however).

**Maximum Economic Yield (MEY):**

"The sustainable yield for a particular stock that, in theory, should give the greatest difference between the value of the fish and the cost of catching them; that is, the best profits" (Gough and Kenchington, 1995).

**Maximum Sustainable Yield (MSY):**

The greatest sustainable yield for a particular stock. In theory, this catch will be sustainable year after year. (Gough and Kenchington, 1995).

It should be noted that MSY occurs at a higher level of fishing mortality than MEY, and despite being the only technical reference point mentioned in the 1982 Convention for the Law of the Sea, is no longer considered a safe target for management for two main reasons: because it is not optimal in economic terms, and because overshoots inevitably occur which are difficult to reverse (Caddy and Mahon, in press).

**Mortality:**

The death of fish. The proportion of the fish dying each year is called the "mortality rate". Scientists express mortality as an exponential rate (see Gulland 1983 for an example): The instantaneous rate is typically referred to by the symbol Z, and scientists attempt to split this overall rate into deaths caused by fishing (F) and all the rest (largely deaths due to predation by other fish or disease (M).

**Nutrients:**

This term is generally used to mean the inorganic ions in sea water essential for maintaining the productivity of phytoplankton. The two most important and commonest ones are nitrate and phosphate, although other related ones (e.g. nitrite and ammonium) play some part. Silicate and carbonate are often considered to be nutrients, although their role is mainly in skeleton formation of certain phytoplankton (and microzooplankton) groups. From the point of view of **sustainable development**, our understanding of the relationship between the amount of each nutrient in the sea water and the productivity of that sea water remains poor, except perhaps at the limits: nitrate and phosphate in too low concentrations prevent phytoplankton production; and in great excess, likewise, but for other physiological and biochemical reasons. In between, their abundance leads to eutrophication, which is discussed in some detail in the present paper, and which is generally regarded as prejudicial to satisfactory resource exploitation and management. It is moreover significant that, although phytoplankton blooms are usually associated with eutrophication (and particularly with high phosphate levels), they also occur in certain times and places in which phosphate levels are very low. It is not possible, with our present understanding, to decide what optimum concentrations might be at a given time and place.

**Overfishing:**

This means catching such a high proportion of one or all age classes in a fishery as to reduce the stock's biomass, spawning potential and future catches, to below safe levels.

**Precautionary approach**:

In cases of high uncertainty about critical areas or species, in particular, and to avoid potentially irreversible changes, the precautionary principle has been advocated in recent years to make development conditional upon scientific proof of its harmlessness. The uncontrolled widespread application of such an approach may, however, conflict with food security considerations.

The **precautionary approach** to regulating the impact of man's activities on natural systems has been adopted in situations where toxic materials are introduced into the marine environment, and is clearly appropriate under circumstances in which the impact of a particular action is clear-cut, or at least is unlikely to have any positive aspects. However, this approach has also been suggested as providing criteria for deciding whether or not, before starting a new fishery, the fishery or type of fishing method used is likely to have damaging effects on ecosystems or on particular species of catch or by-catch, notably, in the latter case, marine mammals and turtles. The validity of applying the principle needs to be considered carefully on a case-by-case basis, and compared with the main alternative strategy: pilot-scale fishing trials at a low level of removal, with scientific observers aboard the fishing vessel.

**Productivity:**

Understanding of ocean productivity has been revolutionized by increased knowledge of the role of microplankton, dissolved organic substances and marine bacteria, including the discovery of an alternative source of bacterial synthesis of organic molecules along the mid-ocean ridges. Perhaps of most relevance to **sustainable development** is the fact that the productivity of most oceanic environments is severely limited by nutrients, trace elements and certain organic compounds; hence our growing realization of the importance of the role of near-shore environments, including the intertidal and supralittoral zones (marshes and wetlands) and riverine inputs, where these substances are generated or run off into coastal waters, in the production of commercial fish species of the continental shelf. The importance of near-shore productivity, especially in the tropics, is only now being translated into a greater concern with the maintenance of these critical habitats, and with the control of the discharge of excess quantities of such substances into coastal waters, where they may produce serious negative effects on the sustainable use of near shore environments and resources. **Productivity** in phytoplankton is a measure of the amount of carbon in the sea water that is converted into living matter in a given volume of that water in a given amount of time (usually measured as milligrammes of chlorophyll **a** and converted, on the basis of experimental evidence, to mg carbon/$m^3$/day). Although this parameter of productivity has been long accepted, it retains many unsatisfactory features, notably that it cannot be measured *in situ ex vitro*. Moreover, the patchiness of phytoplankton, still poorly assessed in the sea, continues to cast doubt on the usefulness of point values. However, our understanding of the mechanisms by which phytoplankters dispose the several forms of chlorophyll and other photosynthetic pigments in their cells so as to be able to extract the maximum amount of energy from the actual light spectrum available *in situ* has also increased considerably in recent years; it significantly qualifies the meaning of simple productivity measurements even if carried out *in vitro in situ*.

The term **production** is often used to mean simply the biomass generated by the population or ecosystem; it is commonly measured as an amount of carbon in living tissue in the water column under a given area of sea surface (usually measured as grammes of chlorophyll **a**, for phytoplankton, or grammes of wet or dry weight, for zooplankton etc., and converted, also on the basis of experimental evidence, to g $C/m^2$; since only the mass of the organisms is of interest, the actual volume of sea occupied is, for such purposes, usually irrelevant). For phytoplankton and, effectively, most of the zooplankton, however, the water column ends at the bottom of the photic zone (that in which enough sunlight penetrates for phytosynthesis to occur). The term **production** is also used more loosely, in fisheries, to mean the catch delivered for human use, or, in fish processing, the amount of product, both for a specified period of time (e.g. year).

**Reciprocity:**

The fact that oceanic environments, their variability and natural fluctuations in resource affect man and his activities has long been recognized. The reverse is now also proving to be the case, with human impacts becoming ever more evident. Likewise, although it has always been clear that the environment affects the biota, the impact that can be caused by exotic organisms introduced into an environment, or explosions in the abundance of native species, such as the crown-of-thorns starfish, can also affect the physical environment.

**Refugium:**

An area where fishing is not allowed, or a consequence of a particular exploitation pattern or method which allows escapement or survival of critical life history stages.

**Resilience:**

Pollution and fishing lead to qualitative and quantitative changes, particularly in semi-enclosed aquatic systems that are an inevitable consequence of human interference. To meet the requirements for **sustainable development** as specified below, it is essential to ask whether the system would be able to return to some predefined 'original state' if this stress were removed; if, for example, future generations decided to use aquatic systems in some completely different fashion. The question of whether a return to some 'original state' is realistic is a controversial one. Natural systems are subject to evolutionary pressures, including extinctions, although these are usually considered to occur on an evolutionary time scale. One might note that overfishing has resulted in relatively few species extinctions in the open marine environment, although, particularly in combination with environmental change, it has been implicated in major changes in species dominance and has particularly serious effects on long-lived species and those with limited areas of critical habitat. Environmental impacts of man, if pronounced, particularly on limited areas of critical or semi-enclosed seas, may provoke more serious long-term effects than 'commercial extinction': the fate of species fished to a level where commercial returns are too low to justify an aimed fishery. For example, high seas overfishing of salmon can reduce populations to a low level, but obstruction of the home estuary would render the population extinct.

**Scale:**

As noted above, the oceans are far from being a homogeneous environment, and a better appreciation of the different time and space scales for various processes appears essential for understanding interconnectedness (see herebelow). Scales may vary from microscale, in seconds and micromillimetres, for understanding the production of phytoplankton and bacteria, to days and 100s of kilometres, for fish recruitment, to years and thousands of kilometres for the Southern Oscillation (encompassing the entire equatorial and South Pacific). This latter, for example, explains the interconnectedness of the El Niño upwelling phenomenon off Peru (which drives the single largest production system for pelagic fish) and drought cycles in Australia. This perception has led to renewed emphasis on incorporation of spatial elements into a synthesis in which geographical information is the key to defining sensitive marine areas and critical habitats, and setting priorities for their appropriate use. The multiple use aspect of marine environments proves to be a major problem here and has led, in the case of coastal zones, to mapping the distribution of human activities and to the application of Geographical Information Systems (GIS) to these areas: an application that needs to be extended farther offshore.

**Stability and Variability**:

In the aquatic environment, sustainability does not necessarily imply constancy: thus, the overall yield may not change markedly as fishing becomes intense, but the relative abundance of species will change, generally in the direction of promoting short-lived species at the expense of longer-lived species. **Stability** is a reflexion of the ability of all the characteristic variables of a population/ecosystem to return to initial equilibrium values following a disturbance that displaces that equilibrium. (The system is locally stable if the return is in response to local perturbations, and globally stable if it is in response to all possible perturbations; perturbations with a negative effect constitute **stress**, whereas those with a positive effect constitute **subsidy**).

Particularly since the 1960s, short-term variations in resource abundance due to environmental fluctuations are recognized as important for assessment and management. These variations are a source of uncertainty and cost to fishery management authorities and industry and can lead to optimistic fleet expansions during good years that result in overfishing, overcapitalization and underemployment in subsequent average-to-poor years. Ideally, annual changes in abundance should be predicted, which still requires combining environmental analysis with resource abundance data from surveys and fishery statistical systems, but the ability to make good predictions, even 1-2 years in advance, has so far proved possible for only a few resources.

The effects of natural climatic fluctuations on living marine resources have also long been appreciated, as has the need to control the type and amount of fishing, but the modification of the theory of fishing, first developed between the two World Wars to take into account the effects of natural environmental change on the productivity of stocks, has been much more recent and still continues. For example, only recently has the extent to which human activities other than fishing may affect marine resources and their optimal usage been appreciated.

**Stock:**

A populaton of fish of one species taken as a whole. It may refer to a genetically isolated population, but more usually in stock assessment, refers to in operational terms, to the population of a species found in a given area, which can effectively be managed as a unit.

**Synergism:**

Human impacts on living marine resources are perceived to be no longer confined to the effects of fishing, but also to include active effects on the environment within which fisheries take place, in addition to the effects of climate. The problem is fundamentally a methodological one, that of distinguishing between two types of causes that have been largely synchronous in their effect on marine systems; namely, the development of industrial fishing capacity, particularly since the Second World War, and the largely synchronous development of the industrial-agricultural complex and its downstream effects on aquatic, including coastal marine, ecosystems. Together with population growth and littoralization (in particular, the development of coastal resorts and international tourism), these factors all affect coastal aquatic environments, directly or indirectly, and have shown a degree of synchrony in their development that makes a separation of their effects difficult.

One approach that seems to offer an insight is to regard most excessive human impacts as different forms of stress on the aquatic system: thus, pollution and overfishing both show parallels, notably a reduction in complexity of the ecosystems involved, reduced efficiency of nutrient cycling, increased amplitude of population fluctuations and, often, a replacement of large, long-lived species by smaller, short-lived species.

**Trace elements:**

These are elements (such as iron, copper and zinc) present in trace quantities in sea water which are essential for the effective functioning of many physiological and biochemical processes, hence for growth, reproduction etc. The relationship between trace elements and nutrients in promoting or restraining growth in phytoplankton is still poorly understood and impedes our understanding of **production** and **productivity**.

# ANNEX II

# LIST OF ACRONYMS

| | |
|---|---|
| CARPAS | Comision Asesora Regional de Pesca para el Atlantico Sudoccidental |
| CCAMLR | Commission for the Conservation of Antarctic Marine Living Resources |
| CECAF | Committee for Eastern Central Atlantic Fisheries |
| CEPTFA | Council of the Eastern Pacific Tuna Fishing Agreement |
| CEU | Commission of the European Union |
| CITES | Convention on International Trade in Exotic Species |
| COFI | Committee on Fisheries (of FAO) |
| CPPS | Comision Permanente del Pacifico Sur |
| DMS | Dimethylsulphide |
| DMSP | Dimethylsulphonium propionate |
| DOALOS | Division of Ocean Affairs and Law of the Sea Office (of UN) |
| EEZ | Exclusive Economic Zone |
| ENSO | El Niño-Southern Oscillation |
| ESCAP | Economic and Social Commission for Asia and the Pacific |
| EU | European Union |
| FAO | Food and Agriculture Organization of the United Nations |
| FFA | Fisheries Forum Agency |
| GEMS | Global Environment Monitoring System |
| GESAMP | Joint Group of Experts on Scientific Aspects of Marine Pollution (of IMO-FAO-UNESCO-WMO-WHO-IAEA-UN-UNEP) |
| GFCM | General Fisheries Council for the Mediterranean (of FAO) |
| GIPME | Global Investigation of Pollution in the Marine Environment (of IOC-UNEP) |
| GIS | Geographic Information System |
| GLOSS | Global Sea-Level Observing System (of IOC) |
| GOOS | Global Ocean Observing System (of IOC) |
| HAB | Harmful Algal Blooms (of OSLR of IOC-FAO) |
| HISMA | High Seas Management Authority |
| IAEA | International Atomic Energy Agency (of UN) |
| IATTC | Inter-American Tropical Tuna Commission |
| IBSFC | International Baltic Sea Fishery Commission |
| ICCAT | International Commission for the Conservation of Atlantic Tuna |
| ICES | International Council for the Exploration of the Sea |
| ICLARM | International Centre for Living Aquatic Resource Management |
| ICSEAF | International Commission for the Southeast Atlantic Fisheries |
| ICSEM | International Commission for the Scientific Exploration of the Mediterranean Sea |
| ICSPRO | Inter-secretariat Committee on Scientific Problems Relating to Oceanography (of UNESCO-FAO-IMO-WMO-UN) |
| ICSU | International Council of Scientific Unions |
| ICZM | Integrated Coastal Zone Management |
| IGBP | International Geosphere-Biosphere Programme (of ICSU) |
| IGOSS | Integrated Global Ocean Services System (of IOC-WMO) |
| IMO | International Maritime Organization |
| INPFC | International North Pacific Fisheries Commission |
| IOC | Intergovernmental Oceanographic Commission (of UNESCO) |
| IOFC | Indian Ocean Fishery Commission (of FAO) |
| IPCC | Intergovernmental Panel on Climate Change (of WMO-UNEP) |
| IPFC | Indo-Pacific Fishery Commission (of FAO) |
| IPHC | International Pacific Halibut Commission |

| | |
|---|---|
| IREP | International Recruitment Programme (of OSLR of IOC-FAO) |
| IUCN | World Wildlife Conservation Organization (formerly International Union for Conservation of Nature and Natural Resources) |
| IWC | International Whaling Commission |
| JKFC | Japan-Republic of Korea Joint Fisheries Commission |
| JSFC | Japan-Soviet Northwest Pacific Fisheries Commission |
| LME | Large Marine Ecosystem |
| MAB | Man and the Biosphere Programme (of UNESCO) |
| MAFF | Ministry of Agriculture, Fisheries and Food (UK) |
| MARPOL | International Convention on the Prevention of Pollution from Ships |
| MBP | Maximum Biological Production |
| MCB | Marine Catchment Basin |
| MCBSF | Mixed Commission for Black Sea Fisheries |
| MCS | Monitoring, Control and Surveillance |
| MEY | Maximum Economic Yield |
| MSY | Maximum Sustainable Yield |
| NAFO | North Atlantic Fisheries Organization |
| NASCO | North Atlantic Salmon Conservation Organization |
| NEAFC | Northeast Atlantic Fisheries Commission |
| NGO | Non-Governmental Organization |
| OAPO | Organizacion Atunera del Pacifico Oriental |
| OCAPAC | Oceans and Coastal Areas Programme Activity Centre (of UNEP) |
| ODAS | Ocean Data Acquisition Systems and Devices (of IMO-IOC) |
| OECS | Organization of Eastern Caribbean States |
| OLDEPESCA | Organizacion Latinoamericana de Desarrollo de la Pesca |
| OSLR | Ocean Science in Relation to Living Resources (of IOC-FAO) |
| OTEC | Ocean Thermal Energy Conversion |
| PCB | Polychlorinated Biphenyl |
| PICES | North Pacific Marine Science Organization |
| PSC | Pacific Salmon Commission |
| SARP | Sardine-Anchovy Recruitment Project (of OSLR of IOC-FAO) |
| SEAFDEC | Southeast Asian Fisheries Development Center |
| SPC | South Pacific Commission |
| TAC | Total Allowable Catch |
| TCDC | Technical Co-operation amongst Developing Countries |
| TEMA | Training, Education and Mutual Assistance in the Marine Sciences (of IOC) |
| TRODERP | Tropical Demersal Recruitment Project (of OSLR of IOC-FAO) |
| TURF | Territorial User Rights of Fishermen |
| UN | United Nations |
| UNCED | United Nations Conference on Environment and Development |
| UNCLOS | United Nations Conference on the Law of the Sea |
| UNDP | United Nations Development Programme |
| UNEP | United Nations Environment Programme |
| UNESCO | United Nations Educational, Scientific and Cultural Organization |
| URI | University of Rhode Island (USA) |
| WB | World Bank (International Bank for Reconstruction and Development) |
| WCRP | World Climate Research Programme (of ICSU-WMO) |
| WECAFC | Western Central Atlantic Fishery Commission (of FAO) |
| WHO | World Health Organization |
| WMO | World Meteorological Organization |
| WWF | World Wildlife Fund for Nature |

# ANNEX III

# SOME INTERNATIONAL ORGANIZATIONS INVOLVED WITH (THE) OCEANIC ENVIRONMENT AND LIVING MARINE RESOURCES

## INTRODUCTION

*The following summaries provide some background information on the roles of key organizations and fishing commissions working in relation to some aspect of living marine resources, their environment and management. For further detailed information on the latter, the reader is referred to reports by Savini (1991) and Marashi (1993).*

### 1. Food and Agriculture Organization of the United Nations (FAO)

FAO has three major departments focussed on resources: Agriculture, Forestry and Fisheries. Within the Fisheries Department there are three main divisions: Fishery Resources; Fishery Industries; and Fishery Policy and Planning.

The Fisheries Department has always placed international focus on the development of fishery science and technology and the transfer of this knowledge to developing countries, through expert technical assistance and fishery research and development projects, the latter calling on a variety of sources of international and donor funding.

With this transfer, a growing degree of self-sufficiency and cooperation is being established in many countries of the developing world, so that, in more recent years, the Department has moved steadily forward with other forms of assistance in the management of fisheries (notably training and development programmes and the organization of intergovernmental and expert consultations).

This trend has been accentuated by the fact that, as knowledge and understanding of the management of fishery resources grew, so did the number of questions requiring an answer, and it was clear from early on that to answer them went beyond the Department's human, financial and physical resources. This is also why technical consultations have increased in number and scope, while direct technical assistance has come to rely less on major international funding, and more on greater national self-help, with the assistance of specialists made available through FAO. This trend has led, in effect, to a more widely-based approach to issues relating to fishery resources, encompassing, as far as possible, consideration of the marine resource and its relationship with environment, its response to fishing, the demand for fish and fish products, the socio-economic role of the fishery and the legal and administrative constraints on fishing, fish processing and marketing.

The FAO World Conference on Fisheries Management and Development (Rome, 1984) marked the integration of FAO's long experience in world fisheries into an overall Strategy for Fisheries Management and Development (FAO, 1986b); the Conference also adopted a series of Programmes of Action, in which broad principles for the sustainable use and protection of marine resources and their habitat were outlined.

At its eighteenth session, in 1989, the FAO Committee on Fisheries reviewed the prospects for capture fisheries, and expressed serious concern about the growing risks and effects of environmental degradation. It urged FAO, through the above-mentioned Programmes of Action, to give higher priority to the monitoring and prevention of environmental degradation in the context of fisheries and aquaculture, and to promote international collaboration to this end. The Organization was also instructed to contribute actively to promoting international agreements on biological/genetic diversity, fisheries and other environmental matters.

The FAO Conference (Rome, 1989), at its twenty-fifth session, decided that the Organization should intensify its inter-disciplinary work so as to integrate environmental considerations into all relevant FAO activities, and give higher priority to the prevention of environmental degradation affecting agriculture, fisheries and forestry, as a result of inappropriate activities in these sectors. The Conference also decided that FAO should strengthen its co-operation with other organizations of the UN System in these fields.

The recommendations of the UN Conference on Environment and Development relevant to fisheries (see section 7.3, above) were incorporated into FAO's Medium-term Programme in Fisheries (1994-1995) by the Committee on Fisheries at its twentieth session (Rome, March 1993), and are summarized in FAO (1992b, 1993g). More recently (See text) emphasis has been placed on development of an International Code of Conduct for Responsible Fisheries Development.

To bring the Department's experience, knowledge and information to bear on regional fishery problems, FAO has created several regional subsidiary bodies, each of which focuses on a particular region and on particular circumstances, with greater or lesser success (depending largely on Member State interest in each region). These bodies are briefly discussed below; the date in parenthesis after each acronym is the date of entry into force. The effectiveness of regional fishery bodies and conventions is discussed in section 7.5, although some of the main constraints of each FAO regional body are taken up in the present section.

### 1.1 FAO regional fishery bodies

The **General Fisheries Council for the Mediterranean** (GFCM; 1952) is concerned not only with fishery development and mangement in the Mediterranean itself, but also with the fisheries of the Black Sea. Since fishery management requires national fishery policy development and application, and the necessary co-operation with other countries, the GFCM has no statutory power to impose any specific fishery management regulation in its region; it therefore emphasizes establishment of an adequate scientific basis for the recommendations

on fishery management that it makes to its Member States. These recommendations are elaborated by expert technical consultations (often at a sub-regional level) and by special committees of the Council, for approval by the Council and submission to Member States (presently, all the countries of the region except those of the former Soviet Union).

The **Indian Ocean Fishery Commission** (IOFC; 1967) covers a much vaster area, (from the Persian Gulf/India/Bay of Bengal, in the north, to the Antarctic Convergence, in the south, from the coast of eastern Africa to the coasts of Thailand, Indonesia and Australia, including Tasmania, in the east). Most of its Member States are developing countries with mainly artisanal/subsistence fisheries and, on the whole, no serious ocean-wide problems of overfishing have yet developed. However, the Indian Ocean tuna and whale resources, in particular, have been subject to high fishing pressure by vessels from countries outside the region. While the IOFC continues its efforts to deal with some important local (sub-regional) fishery problems, a separate Indian Ocean Tuna Commission is picking up work on issues particular to these resources.

The **Indo-Pacific Fishery Commission** (IPFC; 1948) also covers a vast area, from the eastern boundary of the IOFC (with slight overlap) to 180°W, but only north to 45°N. The IPFC's main concern is the development of the fisheries of the large number of small island States (notably, Indonesia, the Philippines, Fiji, Western Samoa, Kiribatu, Tonga and many others). The predominance of Japanese fisheries and the appreciable Russian, Korean and Taiwanese fisheries in this area are also an important concern of the IPFC.

There is **no** FAO regional fishery body in the eastern Pacific, mainly because there are other, non-FAO, sub-regional fishery bodies well established and active there (see 7. below).

The **Western Central Atlantic Fishery Commission** (WECAFC; 1973) has to deal primarily with the development of fisheries in the small island countries of the Caribbean region. It is younger than the aforementioned FAO regional bodies and still has to build up experience of the Member States to use it as a fishery development and management mechanism. The problems of coordination are not helped by the strong polarities in the region, notably those opposing relatively large continental countries and relatively small island countries, and, likewise, Spanish, French-, Dutch to English-speaking traditions contribute to a rich cultural heritage, and lead to subgroupings of countries with common backgrounds, but also contribute to the fragmentation of international co-operation in this region, where international communication systems are still relatively poorly developed, is common in a number of fields unrelated to fisheries. Moreover, the fishery resources themselves are also often fragmented, with stocks sometimes being limited to single islands.

The **Fishery Committee for the Eastern Central Atlantic** (CECAF; 1967) covers the Atlantic from approximately 40°W to the African coast between the Strait of Gibraltar (about 36°N) and Gabon (about 6°S). Its particular problem is the mix of inshore artisanal/subsistence fisheries, on the one hand, and the large-scale offshore pelagic fisheries (notably for sardine), mainly off the coasts of Mauritania and Morocco, and the Gulf of Guinea trawl (demersal) fishery, on the other hand. Once again, the great range of problems and circumstances of the component fisheries makes a single (i.e., sub-regional or regional) fishery development and management approach difficult to implement, although considerable progress has been made in this direction.

FAO also has three important and relatively successful **inland** regional fishery bodies (the European Inland Fisheries Advisory Commission; the Committee on Inland Fisheries of Africa; and the Comité de Pesca para América Latina).

Regarding **co-operation with other UN bodies**, with respect to living marine resources, FAO collaborates particularly with the Intergovernmental Oceanographic Commission (of UNESCO; see section 2) in a programme of Ocean Science in Relation to Living Resources (OSLR). Among the objectives of this programme is the study, through international co-operation, of the mechanisms of recruitment in fish populations (International Recruitment Programme - IREP); particular attention has so far been given to recruitment in sardine-anchovy systems (Sardine-Anchovy Recruitment Project - SARP) since these two types of pelagic fish usually co-exist and interact closely with each other, and to recruitment in tropical demersal communities (Tropical Demersal Recruitment Project -TRODERP). Another main objective of OSLR is the study of algal blooms, their genesis and their role in coastal pelagic ecosystems (Harmful Algal Blooms - HAB). These projects have since been consolidated under one element of OSLR: Ecosystem Dynamics and Living Resources; the other being Support to the Global Ocean Observing System (see section 2).

FAO also collaborated closely with the UN Environment Programme in the development of a Marine Mammal Action Plan. (See also section 3.1).

## 2. Intergovernmental Oceanographic Commission

The Intergovernmental Oceanographic Commission (of UNESCO) plays a key role in defining the physical, chemical and biological factors underlying marine resource use, and in promoting international co-operative investigation and data collection on marine resources and environment. It also promotes Training, Education and Mutual Assistance in the Marine Sciences (TEMA) in oceanography and marine biology. The IOC provides a context for improving understanding of the links between the oceans and climate, and between the oceanic environment and the biological components supporting food chains leading to fisheries, through its efforts to develop a Global Ocean Observing System (GOOS), to which the now well established International Global Ocean Services System (IGOSS) and the Global Sea-level Observing System (GLOSS) are the present mainstays. WMO is participating actively in the development of GOOS, as it already does in IGOSS. IOCs Global Investigation of Pollution in the Marine Environment (GIPME), in which UNEP, IMO, IAEA and FAO also participate, concentrates on chemical pollution, but is nevertheless relevant to the **sustainable development** of marine resources because of the effects of pollutants on marine organisms.

The IOCs International Bathymetric Charts (as well as the longstanding General Bathymetric Chart of the Oceans), being prepared on a regional basis, are also relevant, because of the role of coastal water characteristics in determining overall limits to biological productivity.. A long-term view of IOC's work in the context of **sustainable development** is given in IOC (1991).

## 3. United Nations (UN)

The UN Conference on the Human Environment (Stockholm, 1972) played a key role in focussing the awareness of the international community on the role of the human race in the modification of the environment. The Conference set out (Principles 7 and 21) "a general obligation for states to preserve the marine environment". A great many subsequent legislative actions may be traced back to this recommendation.

The second major UN international consultation particularly relevant to the scope of the present document, was the United Nations Conference on the Law of the Sea (UNCLOS) which provided the necessary legal framework for progress in management of most marine resources; this framework was the 1982 UN Convention on the Law of the Sea, which has been referred throughout this paper. In a comprehensive manner, this calls on each coastal State to promote the objective of optimal utilization of the living resources in its Exclusive Economic Zone (EEZ), in the pursuit of its right to determine the allowable catch of the living resources therein. The significance of the Convention for rational fishery management, hence sustainable development, is given in more detail in Annex IV.

A major milestone in rational use of living resources was the UN Conference on Environment and Development held in Rio in 1992, where the Convention on Biological Diversity (UN 1994, see Annex VIII) was opened for signature, and entered into force on 29 December 1992. This covers the conservation of biological diversity, sustainable use of its components, and equitable sharing of
benefits from genetic resources. In that it provides safeguards for local and traditional uses of these resources, it has obvious fisheries implications, especially with regard to the conservation of critical habitats and endangered species.

More recently, another major United Nations Conference has been underway in New York on "Straddling Fish Stocks and Highly Migratory Fish Stocks" , which has been addressing those issues not fully covered by the 1982 Convention relating to resources that lie across the boundary between Exclusive Economic Zones and the high seas, or migrate through multiple jurisdictions. The conclusions of this Conference are not finalized at the time of writing, but together with the Code of Conduct for Responsible Fisheries being developed by FAO, promise to provide a strong framework for fisheries management in the future.

### 3.1 UN Environment Programme (UNEP)

Although the scope of this Programme is far wider than that of fishery development, one of its main concerns is the state of the marine environment and the impact of human activities on them and on their resources, including therefore fishery resources. The **Oceans and Coastal Areas Programme Activity Centre** (OCAPAC) is UNEP's main instrument for meeting this concern. It covers the ocean environment for the UNEP Global Environment Monitoring System (GEMS). OCAPAC works closely with the other UN intergovernmental bodies, notably with FAO and IOC, and major non-governmental bodies concerned with ocean affairs, generally in the context of the ten UNEP Regional Seas Action Plans.

On the basis of existing agreements aimed at preventing marine pollution from land-based sources, in 1985 UNEP prepared the Montreal Guidelines, which are basically a non-binding checklist of basic provisions that governments may select, adapt or elaborate, as appropriate, to meet the need for reducing adverse impacts on the marine environment.

### 3.2 UN Development Programme (UNDP)

The UN Development Programme promotes the socio-economic development of the developing countries. It does so using funds provided by the UN Member States, through national, regional and inter-regional development projects. These projects are usually of several years' duration. A small percentage of them are in the fishery sector; mostly in inland fisheries where they are associated with rural development as a whole. FAO executes or supervises such projects in the marine sphere, as do other UN Specialized Agencies, and in recent years, UNDP has broadened the base of its executing agencies, including a greater involvement of national entities and experts.

### 3.3 Division of Ocean Affairs and the Law of the Sea (DOALOS)

The Office of Ocean Affairs and the Law of the Sea was created by amalgamating the former Ocean Economics and Technology Branch with the more recent Office of the Under-Secretary-General for the Law of the Sea and was later made a Division. This Division is concerned with a wide range of ocean affairs, of a socio-economic and legal nature; notably, problems of sea-bed mineral exploration and exploitation, the follow-up of the Third UN Conference on the Law of the Sea (and the ratification of the resultant Convention on the Law of the Sea) and the harmonization of relevant national legislation in the light of the Convention, much of which was being incorporated into national law and State practice in many countries, even before the Convention comes into force (November 1994).

DOALOS also prepared guidelines for a high-seas legal framework which will be taken into account in the development, by FAO, of a Code of Conduct on Responsible Fishing called for by the Cancún Declaration (see section 7.2, above).

## 4. International Maritime Organization (IMO)

The IMO is concerned more or less exclusively with shipping: safety of navigation; safety (of seamen and others) at sea; protection of the marine environment from discharges of wastes, pollutants and hazardous substances from ships (including garbage-dumping vessels).

IMO is the depository and secretariat of the global London Convention which regulates the dumping into the sea of wastes and the international Convention for the Prevention of Pollution from Ships (MARPOL 73/78).

IMO is also concerned with mobile offshore drilling units, the safety of fishing vessels and training of fishermen. The IOC collaborates closely with IMO in the marine pollution aspects of IMO's programme of work. More recently, IMO, through the work of its Marine Environment Protection Committee, has focussed on the definition of Sensitive Sea Areas.

## 5. World Meteorological Organization (WMO)

The relation of WMO to fisheries is through its marine meteorological services. Fishing vessels, suitably equipped, can receive weather and sea-state information through the Global Telecommunication System. The long-term objective is to provide all commercial shipping and fishing vessels with real-time (or near-real-time, i.e., within a few hours) information relevant to a vessel's projected track, with advice on appropriate course changes to avoid bad weather (i.e., to save fuel and perhaps time). WMO co-operates with IMO in this field.

In a much more general sense, WMO, through the WMO-ICSU World Climate Research Programme (WCRP), is concerned directly with global climate change (see section 5.10) and this provides a basis for evaluating possible long-term changes in fishery resources. UNEP and IOC participate directly in the WCRP.

## 6. Other UN Agencies

The activities of some other UN Agencies may have some more or less direct relation to certain aspects of fisheries.

The **United Nations Educational, Scientific and Cultural Organization** (UNESCO) publishes checklists of fishes and promotes marine science in general (notably, but not exclusively, through IOC; see section 2. above). The UNESCO Man and the Biosphere (MAB) programme, among other activities of much wider scope, seeks to reveal whole ecosystem linkages and to promote the creation of marine (as well as terrestrial) biosphere reserves.

The **World Health Organization** (WHO) works closely with FAO, through the Codex Alimentarius, on the protection of food, including fish, from all forms of contamination and deterioration (FAO/WHO, 1993).

The **International Atomic Energy Agency** (IAEA) is particularly concerned with, **inter alia**, the contamination of the marine environment and organisms by radio-active substances in the sea.

In co-operation with European Investment Bank and in consultation with other UN Agencies, the **World Bank for Reconstruction and Development** (known informally as the World Bank - WB) unveiled in 1990 a new, more environmentally-conscious approach to investment in marine resource development. An example of this approach is the Environmental Programme for the Mediterranean, an action-oriented programme that incorporates the development of environmental awareness in investment projects for the region. Likewise, the World Bank, with the co-operation of FAO, UNDP and CEC, also carried out the Study of International Fishery Research Needs, which has been referred to earlier (see section 6, above).

## 7. Inter-Agency Co-operation

Several examples have already been given in the foregoing sections, on inter-agency co-operation. This co-operation is generally on a programme basis and sometimes at the regional level through their regional subsidiary bodies. There are, however, two principal mechanisms for more general inter-agency co-operation:

The **UNESCO-FAO-IMO-WMO-UN Inter-Secretariat Committee on Scientific Programmes Relating to Oceanography** (ICSPRO), to meetings of which UNEP and IAEA have nearly always sent active observers, is a mechanism for exchanging information on agency programmes of mutual interest and, as far as possible, for improving co-operation and for co-ordinating actions.

The **IMO/FAO/UNESCO-WMO/WHO/IAEA-UN/UNEP Group of Experts on the Scientific Aspects of Marine Pollution** (GESAMP) produces, *inter alia*, overview reports on the state of the marine environment, such as those published in 1982 (GESAMP, 1982) and 1990 (GESAMP, 1990).

## 8. Some non-UN, International Non-Governmental Organizations

Non-governmental organizations (NGOs) have played a key role in developing environmental awareness with respect to marine resource and environmental issues. They are too numerous to deal with individually; however, the former International Union for Conservation of Nature and Natural Resources (IUCN), now formally titled **World Wildlife Conservation Organization** (with the same acronym, however), can be mentioned as having played a key role outside the UN system. Its World Conservation Strategy (IUCN-UNEP-WWF, 1980) drew the world community's attention to the urgent need for action to conserve habitats and resources. The Strategy has been particularly influential in promoting the concept of **sustainable development**.

## 9. Non-UN Regional Bodies

There are numerous other regional fishery bodies, some being concerned with a particular species or groups of species, others being concerned with fisheries in a particular region. They all have similar general purposes: to assist their members to manage fisheries for which they have been mandated and to provide advice on fishery development in the regions for which they have responsibility. Some have statutory powers, others have only advisory powers. Some may also assist their Member State fishery institutions in such fields as gear development, fishery training, fish-product development, improvement of fishery statistics, and the evaluation of resources (Savini, 1991).

The best known (and the list is far from being exhaustive) are (with the acronym and location of the Secretariat, if known, in parenthesis) given in the following three sub-sections.

### 9.1 Bodies with regional responsibilities

The Northwest Atlantic Fisheries Organization (NAFO, Dartmouth, NS, Canada); the North-East Atlantic Fisheries Commission (NEAFC, London, UK); the International Baltic Sea Fishery Commission (IBSFC, Warsaw, Poland); the Mixed Commission for Black Sea Fisheries (MCBSF, the location of the Secretariat is in the current Chairman's home country and changes frequently); the International North Pacific Fisheries Commission (INPFC, Vancouver, BC, Canada); the Eastern Pacific Tuna Fishing Organization (OAPO, from Organización Atunera del Pacífico Oriental, not yet in force); the Council of the Eastern Pacific Tuna Fishing Agreement (CEPTFA, not yet in force); the Japan-Republic of Korea Joint Fisheries Commission (JKFC; no Secretariat); the Japan-Soviet Northwest Pacific Fisheries Commission (JSFC, no Secretariat); the Permanent Commission for the South Pacific (CPPS, from Comisión Permanente del Pacífico Sur, Santiago, Chile; in fact, CPPS covers the southeast Pacific only, and all forms of maritime wealth, including fisheries, although the latter are important); the South Pacific Forum Fisheries Agency (FFA, Hoiniara, Solomon Islands); the Commission for the Conservation of Antarctic Marine Living Resources (CCAMLR, Hobart, Tasmania, Australia; CCAMLR has somewhat broader responsibilities than those strictly required for fisheries).

### 9.2 Bodies responsible for particular species

The Inter-American Tropical Tuna Commission (IATTC, La Jolla, California, USA; the IATTC covers the eastern Pacific and concerns itself also with billfish fisheries); the International Commission for the Conservation of Atlantic Tuna (ICCAT, Madrid, Spain; ICCAT also concerns itself with billfish fisheries in its area, which also includes the Mediterranean Sea); the International Pacific Halibut Commission (IPHC, Seattle, Washington, USA); the Pacific Salmon Commission (PSC, Vancouver, BC, Canada); the International Whaling Commission (IWC, Cambridge, UK); the North Atlantic Salmon Conservation Organization (NASCO, Edinburgh, UK).

### 9.3 Other related bodies

There are a few regional bodies that have rather broad mandates to study living marine resources and the effect of human exploitation of them. One notable example is ICES (The International Council for the Exploration of the Sea, Copenhagen, Denmark), for which a broad mission statement is given in the box below. They are not limited always to fisheries or may concentrate on only one or two aspects of fisheries. Some are a major source of scientific advice to fishery managers, ministries etc. of their member countries. The following are other well known organizations, but the list is not exhaustive:

The International Centre for Living Aquatic Resources Management (ICLARM, Manila, Philippines); the Southeast Asian Fishery Development Centre (SEAFDEC, Bangkok, Thailand); the International Commission for the Scientific Exploration of the Mediterranean Sea (ICSEM, Monaco); la Organización Latinoamericana de Desarrollo de la Pesca (OLDEPESCA, Lima, Perú); the South Pacific Commission (SPC, Noumea, New Caledonia; it is not be confused with the Permanent Commission for the South Pacific - see 7.4.9.1, above); the Organization of Eastern Caribbean States (OECS); and the North Pacific Marine Science Organizatin (PICES, Sydney, BC, Canada).

Broad Terms of Reference of an International Body Promoting Research and Advice in Fisheries Resources

The International Council for the Exploration of the Sea, hereinafter called "the Council", (1) exists to: a) promote and encourage research and investigations for the study of the sea, particularly related to the living resources thereof; (b) draw up programmes required for this purpose and to organize, in agreement with its Contracting Parties, such research and investigations as may appear necessary; (c) publish or otherwise disseminate the results of this work; and (d) provide scientific information and advice to Member Country governments and the regulatory commissions which they have established; and (2) seeks to establish and maintain working arrangements with other international organizations which have related objectives and cooperate, as far as possible, with such organizations.

# ANNEX IV

# EXTRACTS FROM THE 1982 LAW OF THE SEA CONVENTION OF PARTICULAR RELEVANCE TO LIVING MARINE RESOURCES

## INTRODUCTION

Because of its all-embracing character, the text of the Law of the Sea Convention the text given in UN (1983) covers practically all human activities in the marine environment,and influences institutional thinking and practice in a wide range of spheres.At the same time, our concern is primarily with the use of living marine resources, where the 1982 Convention provides the corner stone for actions by States in their conservation and management. Without providing a substitute for referring to the full text, this annex therefore reproduces frequently used sections of the Convention particularly relevant to the subject of the present document.
Part V of the Convention is where the definition of the Exclusive Economic Zone sets the scene for issues relevant to management and conservation of living marine resources:

## PART V - EXCLUSIVE ECONOMIC ZONE

*Article 55 - Specific legal régime of the exclusive economic zone*

The exclusive economic zone is an area beyond and adjacent to the territorial sea, subject to the specific legal régime established in this Part, under which the rights and jurisdiction of the coastal State and the rights and freedoms of other States are governed by the relevant provisions of this Convention.

*Article 56 - Rights, jurisdiction and duties of the coastal State in the exclusive economic zone*

1. In the exclusive economic zone, the coastal State has:

(a) sovereign rights for the purpose of exploring and exploiting, conserving and managing the natural resources, whether living or non-living, of the waters superjacent to the sea-bed and of the sea-bed and its subsoil, and with regard to other activities for the economic exploitation and exploration of the zone, such as the production of energy from the water, currents and winds;
(b) jurisdiction as provided for in the relevant provisions of this Convention with regard to:
(i) the establishment and use of artificial islands, installations and structures;
(ii) marine scientific research;
(iii) the protection and preservation of the marine environment;
(c) other rights and duties provided for in this Convention.

2. In exercising its rights and performing its duties under this Convention in the exclusive economic zone, the coastal State shall have due regard to the rights and duties of other States and shall act in a manner compatible with the provisions of this Convention.

3. The rights set out in this article with respect to the sea-bed and subsoil shall be exercised in accordance with Part VI.

*Article 57 - Breadth of the exclusive economic zone*

The exclusive economic zone shall not extend beyond 200 nautical miles from the baselines from which the breadth of the territorial sea is measured.

The next series of key Articles introduce the provisions for managing resources of EEZ's:

*Article 61 - Conservation of the living resources*

1. The coastal State shall determine the allowable catch of the living resources in its exclusive economic zone.

2. The coastal State, taking into account the best scientific evidence available to it, shall ensure through proper conservation and management measures that the maintenance of the living resources in the exclusive economic zone is not endangered by over-exploitation. As appropriate, the coastal State and compe tent international organizations, whether subregional, regional or global, shall co-operate to this end.

3. Such measures shall also be designed to maintain or restore populations of harvested species at levels which can produce the maximum sustainable yield, as qualified by relevant environmental and economic factors, including the economic needs of coastal fishing communities and the special requirements of developing States, and taking into account fishing patterns, the interdependence of stocks and any generally recommended international minimum standards, whether subregional, regional or global.

4. In taking such measures the coastal State shall take into consideration the effects on species associated with or dependent upon harvested species with a view to maintaining or restoring populations of such associated or dependent species above levels at which their reproduction may become seriously threatened.

5. Available scientific information, catch and fishing effort statistics, and other data relevant to the conservation of fish stocks shall be contributed and exchanged on a regular basis through competent international organizations, whether subregional, regional or global, where appropriate and with participation by all States concerned, including States whose nationals are allowed to fish in the exclusive economic zone.

*Article 62 - Utilization of the living resources*

1. The coastal State shall promote the objective of optimum utilization of the living resources in the exclusive economic zone without prejudice to article 61.

2. The coastal State shall determine its capacity to harvest the living resources of the exclusive economic zone. Where the coastal State does not have the capacity to harvest the entire allowable catch, it shall, through agree ments or other arrangements and pursuant to the terms, conditions, laws and regulations referred to in paragraph 4, give other States access to the surplus of the allowable catch, having particular regard to the provisions of articles 69 and 70, especially in relation to the developing States mentioned therein.

3. In giving access to other States to its exclusive economic zone under this article, the coastal State shall take into account all relevant factors, including, *inter alia*, the significance of the living resources of the area to the economy of the coastal State concerned and its other national interests, the provisions of articles 69 and 70, the requirements of
developing States in the subregion or region in harvesting part of the surplus and the need to minimize economic dislocation in States whose nationals have habitually fished in the zone or which have made substantial efforts in research and identification of stocks.

4. Nationals of other States fishing in the exclusive economic zone shall comply with the conservation measures and with the other terms and conditions established in the laws and regulations of the coastal State. These laws and regulations shall be consistent with this Convention and may relate, *inter alia*, to the following:

(a) licensing of fishermen, fishing vessels and equipment, including payment of fees and other forms of remuneration, which, in the case of developing coastal States, may consist of adequate compensation in the field of financ ing, equipment and technology relating to the fishing industry;
(b) determining the species which may be caught, and fixing quotas of catch, whether in relation to particular stocks or groups of stocks or catch per vessel over a period of time or to the catch by nationals of any State during a specifled period;
(c) regulating seasons and areas of fishing, the types, sizes and amount of gear, and the types, sizes and number of fishing vessels that may be used;
(d) fixing the age and size of fish and other species that may be caught;
(e) specifying information required of fishing vessels, including catch and effort statistics and vessel position reports;
(f) requiring, under the authorization and control of the coastal State, the conduct of specified fisheries research programmes and regulating the conduct of such research, including the sampling of catches, disposition of samples and reporting of associated scientific data;
(g) the placing of observers or trainees on board such vessels by the coastal State;
(h) the landing of all or any part of the catch by such vessels in the ports of the coastal State;
(i) terms and conditions relating to joint ventures or other cooperative arrangements;
(j) requirements for the training of personnel and the transfer of fisheries technology, including enhancement of the coastal State's capability of undertaking fisheries research;
(k) enforcement procedures .

*Article 63*
*Stocks occurring within the exclusive economic zones of two or more coastal States or both within the exclusive economic zone and in an area beyond and adjacent to it*

1. Where the same stock or stocks of associated species occur within the ex clusive economic zones of two or more coastal States, these States shall seek, either directly or through appropriate subregional or regional organizations, to agree upon the measures necessary to co-ordinate and ensure the conservation and development of such stocks without prejudice to the other provisions of this Part.
2. Where the same stock or stocks of associated species occur both within the exclusive economic zone and in an area beyond and adjacent to the zone, the coastal State and the States fishing for such stocks in the adjacent area shall seek, either directly or through appropriate subregional or regional organiza tions, to agree upon the measures necessary for the conservation of these stocks in the adiacent area.

*Article 64 - Highly migratory species*

1. The coastal State and other States whose nationals fish in the region for the highly migratory species listed in Annex I shall co-operate directly or through appropriate international organizations with a view to ensuring conser vation and promoting the objective of optimum utilization of such species throughout the region, both within and beyond the exclusive economic zone. In regions for which no appropriate international organization exists, the coastal State and other States whose nationals harvest these species in the region shall co-operate to establish such an organization and participate in its work.
2. The provisions of paragraph 1 apply in addition to the other provisions of this Part.

*Article 65 - Marine mammals*

Nothing in this Part restricts the right of a coastal State or the competence of an international organization, as appropriate, to prohibit, limit or regulate the exploitation of marine mammals more strictly than provided for in this Part. States shall co-operate with a view to the conservation of marine mammals and in the case of cetaceans shall in particular work through the appropriate interna tional organizations for their conservation, management and study.

*Article 66 - Anadromous stock*

1. States in whose rivers anadromous stocks originate shall have the primary interest in and responsibility for such stocks.
2. The State of origin of anadromous stocks shall ensure their conservation by the establishment of appropriate regulatory measures for fishing in all waters landward of the outer limits of its exclusive economic zone and for fishing provided for in paragraph 3(b). The State of origin may, after consultations with the other States referred to in paragraphs 3 and 4 fishing these stocks, es tablish total allowable catches for stocks originating in its rivers.
3. (a) Fisheries for anadromous stocks shall be conducted only in waters landward of the outer limits of exclusive economic zones, except in cases where this provision would result in economic dislocation for a State other than the State of origin. With respect to such fishing beyond the outer limits of the exclusive economic zone, States concerned shall maintain consultations with a view to achieving agreement on terms and conditions of such fishing giving due regard to the conservation require ments and the needs of the State of origin in respect of these stocks.

(b) The State of origin shall co-operate in minimizing economic dislocation in such other States fishing these stocks, taking into account the normal catch and the mode of operations of such States, and all the areas in which such fishing has occurred.

(c) States referred to in subparagraph (b), participating by agreement with the State of origin in measures to renew anadromous stocks, particularly by expenditures for that purpose, shall be given special consideration by the State of origin in the harvesting of stocks originating in its rivers.

(d) Enforcement of regulations regarding anadromous stocks beyond the ex clusive economic zone shall be by agreement between the State of origin and the other States concerned.

4. In cases where anadromous stocks migrate into or through the waters landward of the outer limits of the exclusive economic zone of a State other than the State of origin, such State shail co-operate with the State of origin with regard to the conservation and management of such stocks.
5. The State of origin of anadromous stocks and other States fishing these stocks shall make arrangements for the implementation of the provisions of this article, where appropriate, through regionai organizations.

*Article 67 - Catadromous species*

1. A coastal State in whose waters catadromous species spend the greater part of their life cycle shall have responsibility for the management of these spe cies and shall ensure the ingress and egress of migrating fish.
2. Harvesting of catadromous species shall be conducted only in waters land ward of the outer limits of exclusive economic zones. When conducted in exclu sive economic zones, harvesting shall be subject to this article and the other provisions of this Convention concerning fishing in these zones.
3. In cases where catadromous fish migrate through the exclusive economic zone of another State, whether as juvenile or maturing fish, the management, including harvesting, of such fish shall be regulated by agreement between the State mentioned in paragraph 1 and the other State concerned. Such agreement shall ensure the rational management of the species and talce into account the responsibilities of the State mentioned in paragraph 1 for the maintenance of these species.

*Article 68 - Sedentary species*

This Part does not apply to sedentary species as defined in article 77, paragraph 4.

Management and conservation of resources that do not fall under the exclusive jurisdiction of coastal States are dealt with under Section 2 of Part VII "HIGH SEAS".

# PART VII - HIGH SEAS

## SECTION 2. CONSERVATION AND MANAGEMENT OF THE LIVING RESOURCES OF THE HIGH SEAS

*Article 116 - Right to fsh on the high seas*

All States have the right for their nationals to engage in fishing on the high seas subject to:

(a) their treaty obligations;

(b) the rights and duties as well as the interests of coastal States provided for, *interalia,* in article 63, paragraph 2, and articles 64 to 67; and

(c) the provisions of this section.

*Article 117 - Duty of States to adopt with respect to their nationals measures for the conservation of the living resources of the high seas*

All States have the duty to take, or to co-operate with other States in taking, such measures for their respective nationals as may be necessary for the conser vation of the living resources of the high seas.

*Article 118 - Co-operation of States in the conservation and management of living resources*

States shall co-operate with each other in the conservation and management of living resources in the areas of the high seas. States whose nationals exploit identical living resources, or different living resources in the same area, shall enter into negotiations with a view to taking the measures necessary for the con servation of the living resources concerned. They shall, as appropriate, co operate to establish subregional or regional fisheries organizations to this end.

*Article 119 - Conservation of the living resources of the high seas*

1. In determining the allowable catch and establishing other conservation measures for the living resources in the high seas, States shall:

(a) take measures which are designed, on the best scientific evidence avail able to the States concerned, to maintain or restore populations of har vested species at levels which can produce the maximum sustainable yield, as qualifled by relevant environmental and economic factors, including the special requirements of developing States, and taking into account fishing patterns, the interdependence of stocks and any generally recommended international minimum standards, whether subregional, regional or global;

(b) take into consideration the effects on species associated with or depen dent upon harvested species with a view to maintaining or restoring populations of such associated or dependent species above levels at which their reproduction may become seriously threatened.

2. Available scientific information, catch and fishing effort statistics, and other data relevant to the conservation of fish stocks shall be contributed and exchanged on a regular basis through competent international organizations, whether subregional, regional or global, where appropriate and with participa tion by all States concerned.

3. States concerned shall ensure that conservation measures and their imple mentation do not discriminate in form or in fact against the fishermen of any State .

*Article 120 - Marine mammals*

Article 65 also applies to the conservation and management of marine mammals in the high seas.

The concluding sections reproduced here relate to a particular class of marine areas which, as we have seen, are particularly liable to human impacts:

## PART IX

## ENCLOSED OR SEMI-ENCLOSED SEAS

*Article 122 - Definition*

For the purposes of this Convention, "enclosed or semi-enclosed sea" means a gulf, basin or sea surrounded by two or more States and connected to another sea or the ocean by a narrow outlet or consisting entirely or primarily of the territorial seas and exclusive economic zones of two or more coastal States.

*Article 123 - Co-operation of States bordering enclosed or semi-enclosed seas*

States bordering an enclosed or semi-enclosed sea should co-operate with each other in the exercise of their rights and in the performance of their duties under this Convention. To this end they shall endeavour, directly or through an appropriate regional organization:

(a) to co-ordinate the management, conservation, exploration and exploita tion of the living resources of the sea;

(b) to co-ordinate the implementation of their rights and duties with respect to the protection and preservation of the marine environment;

(c) to co-ordinate their scientific research policies and undertake where ap propriate joint programmes of scientific research in the area;

(d) to invite, as appropriate, other interested States or international organi zations to co-operate with them in furtherance of the provisions of this article .

Other Articles have some relevance to the present document but are not reproduced here for lack of space. These are given under the following headings, and can be referred to in UN (1983):

| | |
|---|---|
| Article 143 | Marine scientific research |
| Article 145 | Protection of the marine environment |

(PROTECTION AND PRESERVATION OF THE MARINE ENVIRONMENT (Section 1: **General Provisions)**

| | |
|---|---|
| Article 193 | Sovereign rights of States to exploit their natural resources |
| Article 194 | Measures to prevent, reduce and control pollution of the marine environment |
| Article 196 | Use of technologies or introduction of alien or new species |

(Section 2: **Global and Regional Co-operation**)

| | |
|---|---|
| Article 200 | Studies, research programmes and exchange of information and data |
| Article 201 | Scientific criteria for regulations |

(Section 4: **Monitoring and Environmental Assessment**)

| | |
|---|---|
| Article 206 | Assessment of potential effects of activities |
| Article 207 | Pollution from land-based sources |

(MARINE SCIENTIFIC RESEARCH - Section 1: **General Provisions**)

| | |
|---|---|
| Article 238 | Right to conduct marine scientific research |
| Article 239 | Promotion of marine scientific research |
| Article 240 | General principles for the conduct of marine scientific research |

(Section 2: **International Co-operation**)

| | |
|---|---|
| Article 242 | Promotion of international co-operation |
| Article 243 | Creation of favourable conditions |
| Article 244 | Publication and dissemination of information and knowledge |

(Section 3: **Conduct and Promotion of Marine Scientific Research**)

| | |
|---|---|
| Articles 245-257 | (Thirteen Articles covering various aspects and marine areas) |

# ANNEX V
# THE CANCUN DECLARATION

The key element of the declaration reads as follows:

"CONSIDERING:

The importance of fish products as a source of nutrition for the peoples of the world;

The importance of preserving the marine environment;

That high-seas fisheries have expanded over the last decade, that the management of high-seas fisheries, including the adoption, monitoring and enforcement of effective conservation measures, is inadequate in many areas and that in some areas resources are over-utilized, causing serious concerns for some States with regard to the impact on their fisheries;

The severe problems of excess fishing capacity in many of the world's fisheries;

The need to improve fishing practices and fisheries management to avoid over-exploitation of fisheries resources or loss of biodiversity;

The vital need for fishing to continue and develop within a comprehensive and balanced system under the concept of "responsible fishing";

That this concept encompasses the sustainable utilization of fisheries resources in harmony with the environment; the use of capture and aquaculture practices which are not harmful to ecosystems, resources or their quality; the incorporation of added value to such products through transformation processes meeting the required quality standards; the conduct of commercial practices so as to provide consumers access to good quality products;

The existence of various measures, already adopted, to achieve a better relationship between fishing activities, the conservation of environment and biodiversity, and the recommendations issued by the World Conference on Fisheries Management and Development, convened by the Food and Agriculture Organization of the United Nations (FAO) in 1984;

The relevance of the deliberations of this Conference to the United Nations Conference on Environment and Development (UNCED);

That the United Nations Convention on the Law of the Sea (UNCLOS), done at Montego Bay on 10 December 1982, contains relevant legal principles applying to fishing in areas under national jurisdiction and on the high seas;

The proposal presented within the framework of FAO's Committee on Fisheries during its meeting in April 1991 regarding the drafting of an International Code of Conduct for Responsible Fishing;

**DECLARES**:

1. States[2], with a view to ensuring supply of fish products to feed present and future populations, should adopt effective fisheries planning and management standards which, within the context of sustainable development, will promote the maintenance of the quantity, quality, diversity and economic availability of fisheries resources;

2. States should take steps to improve management systems as part of the practice of responsible fishing. They recognize the principles of sustainable utilization of marine living resources as the basis for sound fisheries management policies. In this regard, they consider as one of the most important objectives the application of policies and measures which result in a level of fishing effort commensurate with the sustainable utilization of fisheries resources taking into account the specific characteristics of particular fisheries;

3. States should improve scientific knowledge regarding the biology, abundance, distribution and fluctuation of fisheries resources, both in their own jurisdictions and on the high seas, taking into account geographic and climatic characteristics;

4. States should promote and enhance collection of data necessary for the conservation and sustainable utilization of fisheries resources;

5. States, in the design and subsequent introduction of new fishing gear and practices, should take into account qualified assessments of impacts on the sustainability of fisheries, giving due consideration to the specific characteristics and biodiversity of different fishing areas;

6. States should promote the development and use of selective fishing gear and practices that minimize waste of catch of target species and minimize by-catch of non-target species;

7. States should systematically assess the impacts of fishing, aquaculture and other activities affecting the marine environment, particularly in coastal areas;

8. States should take necessary measures to protect coastal wetlands and other areas of critical fisheries habitat from all kinds of degradation;

9. States should take measures to ensure respect for the interests of small-scale artisanal and indigenous fishers;

10. States should implement appropriate mechanisms to ensure responsible fishing in exclusive economic zones and other areas under national jurisdcition;

11. States should co-operate on bilateral, regional and multilateral levels to establish, reinforce and implement effective means and mechanisms to ensure responsible fishing on the high seas, in accordance with relevant provisions of UNCLOS;

12. The freedom of States to fish on the high seas must be balanced with the obligation to co-operate with other States to ensure conservation and rational management of the living resources, in accordance with relevant provisions of UNCLOS;

13. States should take effective action, consistent with international law, to deter reflagging of vessels as a means of avoiding compliance with applicable conservation and management rules for fishing activities on the high seas;

14. States should promote educational programmes and dissemination of knowledge about responsible fishing;

---

[2] For the purposes of this Declaration the term "State" should, where appropriate, be read as including the European Community

15. States recognize that environmental policies should deal with the root causes of environmental degradation, thus preventing environmental measures from resulting in unnecessary restrictions to trade. Trade policy measures for environmental purposes should not constitute a means of arbitrary or unjustifiable discrimination or a disguised restriction
on international trade. Unilateral actions to deal with environmental challenges outside the jurisdiction of the importing country should , as far as possible, be based on international consensus. Domestic measures targeted to achieve certain environmental objectives may need trade measures to render them effective. Should trade policy measures be found necessary for enforcement of environmental policies, certain principles and rules should apply. These could include, *inter alia*: the principle of non-discrimination; the principle that the trade measure chosen should be the least trade-restrictive necessary to achieve the objectives; an obligation to ensure transparency in the use of trade measures related to the environment and to provide adequate notification of national regulations; and the need to give consideration to the special conditions and developmental requirements of developing countries as they move toward internationally agreed environmental objectives;

16. States, to promote the objectives of responsible fishing, should foster international co-operation in the development of effective mechanisms of joint research, information exchange and transfer of relevant technology and know-how;

17. International co-operation should include the financial support required by developing countries to enhance their capacity to exercise their sovereign rights by improving their systems for marine scientific research and fisheries management, including surveillance and enforcement;

18. States should enhance international co-operation to prevent illicit fishing that constitutes an obstacle to achieving responsible fishing objectives;

19. International co-operation in responsible fishing should also take the shape of greater financial support for investments by developing countries, channelled through existing international and regional financial organizations, association mechanisms and other forms of co-operation. The goals of that support should be to improve and broaden fishing activity, consistent with responsible fishing, ranging from capture and farm fishing to processes incorporating added value to products destined for domestic consumption and international trade;

20. The implementation of the foregoing principles should be consistent with the sovereign rights, jurisdiction and duties of coastal States within their exclusive economic zones and other areas under national jurisdiction;

The Declaration is completed with an agreement on six formal steps to be taken, based on the foregoing declaration. Most of these formal steps have already been mentioned in earlier sections of this paper, as well as below, so are not reproduced here.

The Declaration of Cancún was conveyed to the Secretary-General of the United Nations, to the Director-General of FAO, and to the Secretary-General of the UN Conference on Environment and Development; it was subsequently brought to the attention of the latter Conference.

The Declaration was submitted to the FAO Council at its hundred and second session (Rome, November 1992). It called on FAO to draft, in consultation with other relevant international
organizations, an International Code of Conduct for Responsible Fishing, in the light of the Declaration as a whole. The Council requested the Director-General to pursue the preparation of a draft of such a code. (Such a draft has just been completed and approved by a technical working group at the time of completion of this document).

# ANNEX VI
# THE RIO DECLARATION

The Rio Declaration has a high relevance with respect to living marine resources (See UNCED, 1994 for more details):

Having met at Rio de Janeiro from 3 to 14 June 1992,

Reaffirming the Declaration of the United Nations Conference on the Human Environment, adopted at Stockholm on 16 June 1972[3], and seeking to build upon it,

With the goal of establishing a new and equitable global partnership through the creation of new levels of cooperation among States, key sectors of societies and people,

Working towards international agreements which respect the interests of all and protect the integrity of the global environmental and developmental system,

Recognizing the integral and interdependent nature of the Earth, our home,

Proclaims that:

PRINCIPLE 1

Human beings are at the centre of concerns for sustainable development. They are entitled to a healthy and productive life in harmony with nature.

PRINCIPLE 2

States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental and developmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction.

PRINCIPLE 3

The right to development must be fulfilled so as to equitably meet developmental and environmental needs of present and future generations.

PRINCIPLE 4

In order to achieve sustainable development, environmental protection shall constitute an integral part of the development process and cannot be considered in isolation from it.

---

[3] Report of the United Nations Conference on the Human Environment, Stockholm 5-16 June (United Nations publication Sales No. E.73.11.A and corrigendum) chapter 1.

PRINCIPLE 5

All States and all people shall cooperate in the essential task of eradicating poverty as an indispensable requirement for sustainable development, in order to decrease the disparities in standards of living and better meet the needs of the majority of the people of the world.

PRINCIPLE 6

The special situation and needs of developing countries, particularly the least developed and those most environmentally vulnerable, shall be given special priority. International actions in the field of environment and development should also address the interests and needs of all countries.

PRINCIPLE 7

States shall co-operate in a spirit of global partnership to conserve, protect and restore the health and integrity of the Earth's ecosystem. In view of the different contributions to global environmental degradation, States have common but differentiated responsibilities. The developed countries acknowledge the responsibility that they bear in the international pursuit of sustainable development in view of the pressures their societies place on the global environment and of the technologies and financial resources they command.

PRINCIPLE 8

To achieve sustainable development and a higher quality of life for all people, States should reduce and eliminate **unsustainable patterns of production and consumption** and promote appropriate demographic policies.

PRINCIPLE 9

States should cooperate to strengthen endogenous capacity-building for sustainable development by improving scientific understanding through exchanges of scientific and technological knowledge, and by enhancing the **development, adaptation, diffusion and transfer of technologies,** including new and innovative technologies.

PRINCIPLE 10

Environmental issues are best handled with the participation of all concerned citizens, at the relevant level. At the national level, each individual shall have appropriate access to information concerning the environment that is held by public authorities, including information on hazardous materials and activities in their communities, and the opportunity to participate in decision-making processes. States shall facilitate and encourage public awareness and participation by making information widely available. Effective access to judicial and administrative proceedings, including redress and remedy, shall be provided.

PRINCIPLE 11

States shall enact effective environmental legislation. Environmental standards, management objectives and priorities should reflect the environmental and developmental context to which they apply. Standards applied by some countries may be inappropriate and of unwarranted economic and social cost to other countries, in particular developing countries.

PRINCIPLE 12

States should co-operate to promote a supportive and open international economic system that would lead to economic growth and sustainable development in all countries, to better address the problems of environmental degradation. Trade policy measures for environmental purposes should not constitute a means of arbitrary or unjustifiable discrimination or a disguised restriction on international trade. Unilateral actions to deal with environmental challenges outside the jurisdiction of the importing country should be avoided. Environmental measures addressing transboundary or global environmental problems should, as far as possible, be based on an international consensus.

PRINCIPLE 13

States shall develop national law regarding liability and compensation for the victims of pollution and other environmental damage. States shall also cooperate in an expeditious and more determined manner to develop further international law regarding liability and compensation for adverse effects of environmental damage caused by activities within their jurisdiction or control to areas beyond their jurisdiction.

PRINCIPLE 14

States should effectively co-operate to discourage or prevent the relocation and transfer to other States of any activities and substances that cause severe environmental degradation or are found to be harmful to human health.

PRINCIPLE 15

In order to protect the environment, the precautionary approach shall be widely applied by States according to their capabilities. Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation.

PRINCIPLE 16

National authorities should endeavour to promote the internalization of environmental costs and the use of economic instruments, taking into account the approach that the polluter should, in principle, bear the cost of pollution, with due regard to the public interest and without distorting international trade and investment.

PRINCIPLE 17

Environmental impact assessment, as a national instrument, shall he undertaken for proposed activities that are likely to have a significant adverse impact on the environment and are subject to a decision of a competent national authority.

PRINCIPLE 18

States shall immediately notify other States of any natural disasters or other emergencies that are likely to produce sudden harmful effects on the environment of those States. Every effort shall be made by the international community to help States so afflicted.

PRINCIPLE 19

States shall provide prior and timely notification and relevant information to potentially affected States on activities that may have a significant adverse transboundary environmental effect and shall consult with those States at an early stage and in good faith.

PRINCIPLE 20

Women have a vital role in environmental management and development. Their full participation is therefore essential to achieve sustainable development.

PRINCIPLE 21

The creativity, ideals and courage of the youth of the world should be mobilized to forge a global partnership in order to achieve sustainable development and ensure a better future for all.

PRINCIPLE 22

Indigenous people and their communities and other local communities have a vital role in environmental management and development because of their knowledge and traditional practices. States should recognize and duly support their identity, culture and interests and enable their effective participation in the achievement of sustainable development.

PRINCIPLE 23

The environment and natural resources of people under oppression, domination and occupation shall be protected.

PRINCIPLE 24

Warfare is inherently destructive of sustainable development. States shall therefore respect international law providing protection for the environment in times of armed conflict and cooperate in its further development, as necessary.

PRINCIPLE 25

Peace, development and environmental protection are interdependent and indivisible.

PRINCIPLE 26

States shall resolve all their environmental disputes peacefully and by appropriate means in accordance with the Charter of the United Nations.

PRINCIPLE 27

States and people shall cooperate in good faith and in a spirit of partnership in the fulfilment of the principles embodied in this Declaration and in the further development of international law in the field of sustainable development.

# ANNEX VII
# EXTRACTS FROM AGENDA 21 FOR THE OCEANS

At the Earth Summit in Rio de Janeiro (1992), a global agenda for action in support of Sustainable Development. Many aspects of this plan of action are of general interest, and the reader is referred to UNCED (1992) for details. With respect to oceans, their environment and resources, the more specific elements are aimed at:

*"Protection of the oceans, all kinds of seas, including enclosed and semi-enclosed seas, and coastal areas and the protection, rational use and development of their living resources"*

New approaches are proposed within Agenda 21 for the Oceans to marine and coastal area management and development, at the national, subregional, regional and global levels; approaches that are integrated in content and are precautionary and anticipatory in ambit, as reflected in the following programme areas:

(a) Integrated management and sustainable development of coastal areas, including exclusive economic zones;
(b) Marine environmental protection;
(c) Sustainable use and conservation of marine living resources of the high seas;
(d) Sustainable use and conservation of marine living resources under national jurisdiction;
(e) Addressing critical uncertainties for the management of the marine environment and climate change;
(f) Strengthening international, including regional, co-operation and coordination;
(g) Sustainable development of small islands.

A tentative costing of global action on this entire programme was spilt between the above programme areas. For each programme area, a brief description of the basis for action, the objectives, the activities (management-related, necessary data and information, and international cooperation), and the means of implementation (financial, scientific, technological, human resource development and capacity building), were outlined. The implementation by developing countries of theese activities was agreed to be commensurate with their individual technological and financial capacities and priorities in allocating resources for development needs and ultimately depended on the technology transfer and financial resources required and made available to them.

The text for two programme areas of particular relevance to this report is reproduced below:

## C) SUSTAINABLE USE AND CONSERVATION OF MARINE LIVING RESOURCES OF THE HIGH SEAS

BASIS FOR ACTION

17.44 Over the last decade, fisheries on the high seas have considerably expanded and currently represent approximately 5 percent of total world landings. The provisions of the United Nations Convention on the Law of the Sea on the marine living resources of the high seas sets forth rights and obligations of States with respect to conservation and utilization of those resources.

17.45 However, management of high seas fisheries, including the adoption, monitoring and enforcement of effective conservation measures, is inadequate in many areas and some resources are overutilized. There are problems of unregulated fishing, overcapitalization, excessive fleet size, vessel reflagging to escape controls, insufficiently selective gear, unreliable databases and lack of sufficient cooperation between States. Action by States whose nationals and vessels fish on the high seas, as well as cooperation at the bilateral, subregional,

regional and global levels, is essential particularly for highly migratory species and straddling stocks. Such action and cooperation should address inadequacies in fishing practices, as well as in biological knowledge, fisheries statistics and improvement of systems for handling data. Emphasis should also be on multi-species management and other approaches that take into account the relationships among species, especially in addressing depleted species, but also in identifying the potential of underutilized or unutilized populations.

OBJECTIVES

17.46 States commit themselves to the conservation and sustainable use of marine living resources on the high seas. To this end, it is necessary to:

(a) Develop and increase the potential of marine living resources to meet human nutritional needs, as well as social, economic and development goals;

(b) Maintain or restore populations of marine species at levels that can produce the maximum sustainable yield as qualified by relevant environmental and economic factors, taking into consideration relationships among species;

(c) Promote the development and use of selective fishing gear and practices that minimize waste in the catch of target species and minimize by-catch of non-target species

(d) Ensure effective monitoring and enforcement with respect to fishing activities;

(e) Protect and restore endangered marine species;

(f) Preserve habitats and other ecologically sensitive areas;

(g) Promote scientific research with respect to the marine living resources in the high seas.

17.47 Nothing in paragraph 17.46 above restricts the right of a State or the competence of an international organization, as appropriate, to prohibit, limit or regulate the exploitation of marine mammals on the high seas more strictly than provided for in that paragraph. States shall cooperate with a view to the conservation of marine mammals and, in the case of cetaceans, shall in particular work through the appropriate international organizations for their conservation, management and study.

17.48 The ability of developing countries to fulfil the above objectives is dependent upon their capabilities, including the financial, scientific and technological means at their disposal. Adequate financial, scientific and technological cooperation should be provided to support action by them to implement these objectives.

ACTIVITIES

**A) MANAGEMENT-RELATED ACTIVITIES**

17.49 States should take effective action, including bilateral and multilateral cooperation, where appropriate at the subregional, regional and global levels, to ensure that high seas fisheries are managed in accordance with the provisions of the United Nations Convention on the Law of the Sea. In particular, they should:

(a) Give full effect to these provisions with regard to fisheries populations whose ranges lie both within and beyond exclusive economic zones (straddling stocks);

(b) Give full effect to these provisions with regard to highly migratory species;

(c) Negotiate, where appropriate, international agreements for the effective management and conservation of fishery stocks;

(d) Define and identify appropriate management units;

17.50 States should convene, as soon as possible, an intergovernmental conference under United Nations auspices, taking into account relevant activities at the subregional, regional and global levels, with a view to promoting effective implementation of the provisions of the United Nations Convention on the Law of the Sea on straddling fish stocks and highly migratory fish stocks. The conference, drawing, *inter alia*, on scientific and technical studies by FAO, should
identify and assess existing problems related to the conservation and management of such fish stocks, and consider means of improving cooperation on fisheries among States, and formulate appropriate recommendations. The work and the results of the conference should be fully consistent with the provisions of the United Nations Convention on the Law of the Sea, in particular the rights and obligations of coastal States and States fishing on the high seas.

17.51 States should ensure that fishing activities by vessels flying their flags on the high seas take place in a manner so as to minimize incidental catches.

17.52 States should take effective action consistent with international law to monitor and control fishing activities by vessels flying their flags on the high seas to ensure compliance with applicable conservation and management rules, including full, detailed, accurate and timely reporting of catches and effort.

17.53 States should take effective action, consistent with international law, to deter reflagging of vessels by their nationals as a means of avoiding compliance with applicable conservation and management rules for fishing activities on the high seas.

17.54 States should prohibit dynamiting, poisoning and other comparable destructive fishing practices.

17.55 States should fully implement General Assembly resolution 46/215 on large-scale pelagic drift-net fishing.

17.56 States should take measures to increase the availability of marine living resources as human food by reducing wastage, post-harvest losses and discards, and improving techniques of processing, distribution and transportation.

**B) DATA AND INFORMATION**

17.57 States, with the support of international organizations, whether subregional, regional or global, as appropriate, should cooperate to:

(a) Promote enhanced collection of data necessary for the conservation and sustainable use of the marine living resources of the high seas;

(b) Exchange on a regular basis up-to-date data and information adequate for fisheries assessment;

(c) Develop and share analytical and predictive tools, such as stock assessment and bioeconomic models;

(d) Establish or expand appropriate monitoring and assessment programmes.

**C) INTERNATIONAL AND REGIONAL COOPERATION AND COORDINATION**

17.58 States, through bilateral and multilateral cooperation and within the framework of subregional and regional fisheries bodies, as appropriate, and with the support of other international intergovernmental agencies, should assess high seas resource potentials and develop profiles of all stocks (target and non-target).

17.59 States should, where and as appropriate, ensure adequate coordination and cooperation in enclosed and semi-enclosed seas and between subregional, regional and global intergovernmental fisheries bodies.

17.60 Effective cooperation within existing subregional, regional or global fisheries bodies should be encouraged. Where such organizations do not exist, States should, as appropriate, cooperate to establish such organizations.

17.61 States with an interest in a high seas fishery regulated by an existing subregional and/or regional high seas fisheries organization of which they are not members should be encouraged to join that organization, where appropriate.

17.62 States recognize:

(a) The responsibility of the International Whaling Com mission for the conservation and management of whale stocks and the regulation of whaling pursuant to the 1946 International Convention for the Regulation of Whaling;

(b) The work of the International Whaling Commission Scientific Committee in carrying out studies of large whales in particular, as well as of other cetaceans;

(c) The work of other organizations, such as the Inter-American Tropical Tuna Commission and the Agreement on Small Cetaceans in the Baltic and North Sea under the Bonn Convention, in the conservation, management and study of cetaceans and other marine mammals.

17.6 States should cooperate for the conservation, management and study of cetaceans.

MEANS OF IMPLEMENTATION

**A) FINANCING AND COST EVALUATION**

17.64 The Conference secretariat has estimated the average total annual cost (1993-2000) of implementing the activities of this programme to be about $12 million from the international community on grant or concessional terms. These are indicative and order-of-magnitude estimates only and have not been reviewed by Governments. Actual costs and financial terms, including any that are non-concessional, will depend upon, *inter alia,* the specific strategies and programmes Governments decide upon for implementation.

**B) SCIENTIFIC AND TECHNOLOGICAL MEANS**

17.65 States, with the support of relevant international organizations, where necessary, should develop collaborative technical and research programmes to improve understanding of the life cycles and migrations of species found on the high seas, including identifying critical areas and life stages.

17.66 States, with the support of relevant international organizations, whether subregional, regional or global, as appropriate, should:

(a) Develop databases on the high seas marine living resources and fisheries;

(b) Collect and correlate marine environmental data with high seas marine living resources data, including the impacts of regional and global changes brought about by natural causes and by human activities;

(c) Cooperate in coordinating research programmes to provide the knowledge necessary to manage high seas resources.

## C) HUMAN RESOURCE DEVELOPMENT

17.67 Human resource development at the national level should be targeted at both development and management of high seas resources, including training in high seas fishing techniques and in high seas resource assessment, strengthening cadres of personnel to deal with high seas resource management and conservation and related environmental issues, and training observers and inspectors to be placed on fishing vessels.

## D) CAPACITY-BUILDING

17.68 States, with the support, where appropriate, of relevant international organizations, whether sub regional, regional or global, should cooperate to develop or upgrade systems and institutional structures for monitoring, control and surveillance, as well as the research capacity for assessment of marine living resource populations.

17.69 Special support, including cooperation among States, will be needed to enhance the capacities of developing countries in the areas of data and information, scientific and technological means, and human resource development in order to participate effectively in the conservation and sustainable utilization of high seas marine living resources.

## E) SUSTAINABLE USE AND CONSERVATION OF MARINE LIVING RESOURCES UNDER NATIONAL JURISDICTION

### BASIS FOR ACTION

17.70 Marine fisheries yield 80 to 90 million tons of fish and shellfish per/year, 95 per cent of which is taken from waters under national jurisdiction. Yields have increased nearly fivefold over the past four decades. The provisions of the United Nations Convention on the Law of the Sea on marine living resources of the exclusive economic zone and other areas under national jurisdiction set forth rights and obligations of States with respect to conservation and utilization of those resources.

17.71 Marine living resources provide an important source of protein in many countries and their use is often of major importance to local communities and indigenous people. Such resources provide food and livelihoods to millions of people and, if sustainably utilized, offer increased potential to meet nutritional and social needs, particularly in developing countries. To realize this potential requires improved knowledge and identification of marine living resource stocks, particularly of underutilized and unutilized stocks and species, use of new technologies, better handling and processing facilities to avoid wastage, and improved quality and training of skilled personnel to manage and conserve effectively the marine living resources of the exclusive economic zone and other areas under national jurisdiction. Emphasis should also be on multi-species management and other approaches that take into account the relationships among species.

17.72 Fisheries in many areas under national jurisdiction face mounting problems, including local overfishing, unauthorized incursions by foreign fleets, ecosystem degradation, overcapitalization and excessive fleet sizes, underevaluation of catch, insufficiently selective gear, unreliable databases, and increasing competition between artisanal and large-scale fishing, and between fishing and other types of activities.

17.73 Problems extend beyond fisheries. Coral reefs and other marine and coastal habitats, such as mangroves and estuaries, are among the most highly diverse, integrated and productive of the Earth's ecosystems. They often serve important ecological functions, provide coastal protection, and are critical resources for food, energy, tourism and economic development. In many parts of the world, such marine and coastal systems are under stress or are threatened from a variety of sources, both human and natural.

OBJECTIVES

17.74 Coastal States, particularly developing countries and States whose economies are overwhelmingly dependent on the exploitation of the marine living resources of their exclusive economic zones, should obtain the full social and economic benefits from sustainable utilization of marine living resources within their exclusive economic zones and other areas under national jurisdiction.

17.75 States commit themselves to the conservation and sustainable use of marine living resources under national jurisdiction. To this end, it is necessary to:

(a) Develop and increase the potential of marine living resources to meet human nutritional needs, as well as social, economic and development goals,

(b) Take into account traditional knowledge and interests of local communities, small-scale artisanal fisheries and indigenous people in development and management programmes;

(c) Maintain or restore populations of marine species at levels that can produce the maximum sustainable yield as qualified by relevant environmental and economic factors, taking into consideration relationships among species;

(d) Promote the development and use of selective fishing gear and practices that minimize waste in the catch of target species and minimize by-catch of non-target species;

(e) Protect and restore endangered marine species;

(f) Preserve rare or fragile ecosystems, as well as habitats and other ecologically sensitive areas.

17.76 Nothing in paragraph 17.75 above restricts the right of a coastal State or the competence of an international organization, as appropriate, to prohibit, limit or regulate the exploitation of marine mammals more strictly than provided for in that paragraph. States shall cooperate with a view to the conservation of marine mammals and in the case of cetaceans shall in particular work through the appropriate international organizations for their conservation, management and study.

17.77 The ability of developing countries to fulfil the above objectives is dependent upon their capabilities, including the financial, scientific and technological means at their disposal. Adequate financial, scientific and technological cooperation should be provided to support action by them to implement these objectives.

ACTIVITIES

**A) MANAGEMENT-RELATED ACTIVITIES**

17.78 States should ensure that marine living resources of the exclusive economic zone and other areas under national jurisdiction are conserved and managed in accordance with the provisions of the United Nations Convention on the Law of the Sea.

17.79 States, in implementing the provisions of the United Nations Convention on the Law of the Sea, should address the issues of straddling stocks and highly migratory species, and, taking fully into account the objective set out in paragraph 17.74, access to the surplus of allowable catches.

17.80 Coastal States, individually or through bilateral, and/or multilateral cooperation and with the support, as appropriate of international organizations, whether sub regional, regional or global, should *inter alia*:

(a) Assess the potential of marine living resources, including underutilized or unutilized stocks and species, by developing inventories, where necessary, for their conservation and sustainable use;

(b) Implement strategies for the sustainable use of marine living resources, taking into account the special needs and interests of small-scale artisanal fisheries, local communities and indigenous people to meet human nutritional and other development needs;

(c) Implement, in particular in developing countries, mechanisms to develop mariculture, aquaculture and small-scale, deep-sea and oceanic fisheries within areas under national jurisdiction where assessments show that marine living resources are potentially available;

(d) Strengthen their legal and regulatory frameworks, where appropriate, including management, enforcement and surveillance capabilities, to regulate activities related to the above strategies;

(e) Take measures to increase the availability of marine living resources as human food by reducing wastage, post-harvest losses and discards, and improving techniques of processing, distribution and transportation;

(f) Develop and promote the use of environmentally sound technology under criteria compatible with the sustainable use of marine living resources, including assessment of the environmental impact of major new fishery practices;

(g) Enhance the productivity and utilization of their marine living resources for food and income.

17.81 Coastal States should explore the scope for expanding recreational and tourist activities based on marine living resources, including those for providing alternative sources of income. Such activities should be compatible with conservation and sustainable development policies and plans.

17.82 Coastal States should support the sustainability of small-scale artisanal fisheries. To this end, they should, as appropriate:

(a) Integrate small-scale artisanal fisheries development in marine and coastal planning, taking into account the interests and, where appropriate, encouraging representation of fishermen, small-scale fisherworkers, women, local communities and indigenous people;

(b) Recognize the rights of small-scale fishworkers and the special situation of indigenous people and local communities, including their rights to utilization and protection of their habitats on a sustainable basis;

(c) Develop systems for the acquisition and recording of traditional knowledge concerning marine living resources and environment and promote the incorporation of such knowledge into management systems.

17.83 Coastal States should ensure that, in the negotiation and implementation of international agreements on the development or conservation of marine living resources, the interests of local communities and indigenous people are taken into account, in particular their right to subsistence.

17.84 Coastal States, with the support, as appropriate, of international organizations should conduct analyses of the potential for aquaculture in marine and coastal areas under national jurisdiction and apply appropriate safeguards as to the introduction of new species.

17.85 States should prohibit dynamiting, poisoning and other comparable destructive fishing practices.

17.86 States should identify marine ecosystems exhibiting high levels of biodiversity and productivity and other critical habitat areas and should provide necessary limitations on use in these areas, through, *inter alia*, designation of protected areas. Priority should be accorded, as appropriate, to:

(a) Coral reef ecosystems;

(b) Estuaries;

(c) Temperate and tropical wetlands, including mangroves;

(d) Seagrass beds;

(e) Other spawning and nursery areas.

**B) DATA AND INFORMATION**

17.87 States, individually or through bilateral and multilateral cooperation and with the support, as appropriate, of international organizations, whether subregional, regional or global, should:

(a) Promote enhanced collection and exchange of data necessary for the conservation and sustainable use of the marine living resources under national jurisdiction;

(b) Exchange on a regular basis up-to-date data and information necessary for fisheries assessment;

(c) Develop and share analytical and predictive tools, such as stock assessment and bioeconomic models;

(d) Establish or expand appropriate monitoring and assessment programmes;

(e) Complete or update marine biodiversity, marine living resource and critical habitat profiles of exclusive economic zones and other areas under national jurisdiction, taking account of changes in the environment brought about by natural causes and human activities.

**C) INTERNATIONAL AND REGIONAL COOPERATION AND COORDINATION**

17.88 States, through bilateral and multilateral cooperation, and with the support of relevant United Nations and other international organizations, should cooperate to:

(a) Develop financial and technical cooperation to enhance the capacities of developing countries in small scale and oceanic fisheries, as well as in coastal aquaculture and mariculture;

(b) Promote the contribution of marine living resources to eliminate malnutrition and to achieve food self-sufficiency in developing countries, *inter alia,* by minimizing post-harvest losses and managing stocks for guaranteed sustainable yields;

(c) Develop agreed criteria for the use of selective fishing gear and practices to minimize waste in the catch of target species and minimize by-catch of non-target species;

(d) Promote seafood quality, including through national quality assurance systems for seafood, in order to promote access to markets, improve consumer confidence and maximize economic returns.

17.89 States should, where and as appropriate, ensure adequate coordination and cooperation in enclosed and semi-enclosed seas and between subregional, regional and global intergovernmental fisheries bodies.

17.90 States recognize:

(a) The responsibility of the International Whaling Commission for the conservation and management of whale stocks and the regulation of whaling pursuant to the 1946 International Convention for the Regulation of Whaling;

(b) The work of the International Whaling Commission Scientific Committee in carrying out studies of large whales in particular, as well as of other cetaceans;

(c) The work of other organizations, such as the Inter-American Tropical Tuna Commission and the Agreement on Small Cetaceans in the Baltic and North Sea under the Bonn Convention, in the conservation, management and study of cetaceans and other marine mammals.

17.91 States should cooperate for the conservation, management and study of cetaceans.

## MEANS OF IMPLEMENTATION

### A) FINANCING AND COST EVALUATION

17.92 The Conference secretariat has estimated the average total annual cost (1993-2000) of implementing the activities of this programme to be about $6 billion, including about $60 million from the international community on grant or concessional terms. These are indicative and order-of-magnitude estimates only and have not been reviewed by Governments. Actual costs will depend upon, *inter alia*, the specific strategies and programmes Governments decide upon for implementation.

### B) SCIENTIFIC AND TECHNOLOGICAL MEANS

17.93 States, with the support of relevant intergovernmental organizations, as appropriate, should:

(a) Provide for the transfer of environmentally sound technologies to develop fisheries, aquaculture and mariculture, particularly to developing countries;

(b) Accord special attention to mechanisms for transferring resource information and improved fishing and aquaculture technologies to fishing communities at the local level;

(c) Promote the study, scientific assessment and use of appropriate traditional management systems;

(d) Consider observing, as appropriate, the FAO/ICES Code of Practice for Consideration of Transfer and Introduction of Marine and Freshwater Organisms;

(e) Promote scientific research on marine areas of particular importance for marine living resources, such as areas of high diversity, endemism and productivity and migratory stopover points.

### C) HUMAN RESOURCE DEVELOPMENT

17.94 States individually, or through bilateral and multilateral cooperation and with the support of relevant international organizations, whether subregional, regional or global, as appropriate, should encourage and provide support for developing countries, *inter alia,* to:

(a) Expand multidisciplinary education, training and research on marine living resources, particularly in the social and economic sciences;

(b) Create training opportunities at national and regional levels to support artisanal (including subsistence) fisheries to develop small-scale use of marine living resources and to encourage equitable participation of local communities, small-scale fish workers, women and indigenous people;

(c) Introduce topics relating to the importance of marine living resources in educational curricula at all levels.

**D) CAPACITY-BUILDING**

17.95 Coastal States, with the support of relevant subregional, regional and global agencies, where appropriate, should:

(a) Develop research capacities for assessment of marine living resource populations and monitoring;

(b) Provide support to local fishing communities, in particular those that rely on fishing for subsistence, indigenous people and women, including, as appropriate, the technical and financial assistance to organize, maintain, exchange and improve traditional knowledge of marine living resources and fishing techniques, and up grade knowledge on marine ecosystems;

(c) Establish sustainable aquaculture development strategies, including environmental management in support of rural fish-farming communities;

(d) Develop and strengthen, where the need may arise, institutions capable of implementing the objectives and activities related to the conservation and management of marine living resources.

17.96 Special support, including cooperation among States, will be needed to enhance the capacities of developing countries in the areas of data and information, scientific and technological means and human resource development in order to enable them to participate effectively in the conservation and sustainable use of marine living resources under national jurisdiction.

# ANNEX VIII
# THE UNITED NATIONS CONVENTION ON BIOLOGICAL DIVERSITY

This Convention is of course much broader in scope than marine resources, but has direct relevance to their appropriate use. Three main objectives of this Convention are mentioned in section 1 of UN (1994);

(a) the conservation of biological diversity, defined as:

"the variability among living organisms from all sources including, *inter alia,* terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species, and of ecosystems";

(b) their sustainable use;

(c) the fair and equitable sharing of benefits arising out of the utilization of genetic resources, including appropriate access to these resources and the transfer of appropriate technologies.

From the above, it is clear that two types of diversity are covered: genetic diversity (e.g. of a single species) which has immediate relevance to biotechnology, defined as "any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for specific use"; and species conservation, the associated ecological diversity of species complexes, and the habitats needed to support these ecosystems. The first of the economic uses of marine (genetic) biodiversity is already relevant to marine aquaculture, and will undoubtedly become more important in the future. The second relates to the conservation of species, ecosystems, and the habitats necessary for their survival, and is of immediate concern to fisheries and their sustainable use.

With respect to jurisdiction, a distinction is made between components of biological diversity which lie within areas of national jurisdiction where the sovereign right to exploit them is recognized; but a supplementary responsibility is given not to damage resources lying beyond national responsibility by processes or activities on national territory where these effects have an impact beyond national jurisdiction.

National strategies are mandated for conservation and sustainable use of biodiversity, including the identification and monitoring of the same, and their conservation.

The Article on 'In-situ Conservation' requires that a system of protected areas should be established, with environmentally sound policies applied, especially in adjacent areas, but also in the national territory as a whole. Degraded ecosystems are to be restored, recovery of threatened species promoted, indigenous knowledge of resources preserved. Financial support is to be provided for these efforts as well as appropriate legislation.

The Convention provides for meeting the above requirement through incentives, research and training and public education and awareness.

In the case of marine fisheries, this Convention has obvious direct relevance to many of the issues covered by other international agreements discussed in this document, and the reader is referred to UN (1994) for further details, which go beyond the scope of this brief description.

This document provides a broad perspective on issues related to living marine resources, their environment and management in the wake of the United Nations Conference on Environment and Development and the Cancun Conference. The document begins with a sectoral discussion of sustainable development of living resources of nearshore and estuarine, semi-enclosed seas, coastal and shelf waters, the high seas and Antarctic waters. Constraints on harvesting, impacts of marine pollution and potential for further development of resources are addressed. Each section concludes with a discussion of elements that can be included in a resource management programme. References are given for key literature related to the themes discussed. The annexes provide a glossary of key concepts, list of acronyms, lists of fisheries commissions and international organizations concerned with marine affairs, and excerpts from conventions and other international agreements concerning living marine resources and their environment.

ISBN 92-5-103763-9 ISSN 0429-9345

9 789251 037638

M-43 V5321E/1/11.95/2500